

Session 1: Fatal Construction Injuries

Guiding Construction Injury Research: Data Coupled with Industry Experience—Fosbroke D, Casini V, Furrow K, Hause M, Linn H, Washenitz F

In 1996, the National Institute for Occupational Safety and Health (NIOSH), Division of Safety Research (DSR) initiated a process of examining current construction injury research, identifying research gaps, and developing a strategic research plan. Through existing injury surveillance data systems, much is known about the leading causes of fatal (falls, motor vehicles, machines, and electrocutions) and nonfatal injury (overexertion, falls, and struck by objects) in the construction industry; however, little research has focused on identifying injury problems for specific subsectors of the construction industry. Research that is focused on specific injury problems and specific types of construction work (e.g., falls during truss installation) may lead more directly to identification of effective interventions than research on general injury categories in the construction industry as a whole (e.g., falls in construction). Three high-risk construction industry sectors (highway and street construction, residential building construction, and roofing and truss installation) were selected based on a review of fatal and nonfatal injury data, the number of workers at risk, current trends in the construction industry, OSHA's regulatory agenda, an external panel evaluation of The National Program for Occupational Safety and Health in Construction, the National Occupational Research Agenda, and DSR expertise and research projects. For each industry sector, NIOSH conducted a facilitated workshop with participants from labor unions, construction companies, contractor associations, product manufacturers, insurance companies, and State and federal agencies. DSR staff identified brainstorming topics for each workshop based on the leading causes of fatal and nonfatal injury for that industry subsector. Brainstorming topics included motor vehicle incidents, falls from elevation, "struck by" incidents, and overexertion. Workshop participants were asked to suggest potential safety research ideas that could lead to a reduction of injuries from these causes in their industry sectors.

Each workshop yielded a list of more than 100 ideas about general problem areas where the participants felt further research was warranted. Following each workshop, NIOSH staff, with the assistance of federal partners, used a multivoting technique to narrow these lists to approximately 30 ideas for further study. Some suggestions were very specific (e.g., design a fall restraint system for workers riding in pickup truck beds while placing or removing traffic cones); others were broad in scope (evaluate the effectiveness of training). Other broad themes that crossed industry sector and injury categories included the following: identify high-risk construction tasks, activities, processes, and stages; improve the quality and coverage of surveillance data; develop new, or adapt existing technologies to the unique conditions of specific industries; compare the relative risks of different types of construction projects; study the relationship of training, experience, and injury; improve partnerships among research organizations, industry, and labor; and improve, simplify, and more effectively disseminate safety information. The process of combining injury surveillance data with the experience of individuals in the affected industries provided NIOSH researchers with a broader perspective on the safety research needs of the construction industry.

Work-related Fatal Injury Risk of Construction Workers by Occupation and Cause of Death—Chen G-X, Fosbroke D

Background. Construction is both one of the largest and one of the most dangerous industries in the United States, but there is little literature on fatality risk by occupation within this industry. This study assessed work-related injury fatality risk by occupation and cause of death within the construction industry, using data contained in the NIOSH National Traumatic Occupational Fatality (NTOF) surveillance system and the BLS Current Population Survey (CPS) from 1990 to 1991.

Method. Annual fatality rates were calculated for occupations with six or more work-related injury deaths during the 2-year period and presented as the number of deaths per 100,000 workers. Cause-specific annual rates were also calculated for occupations with 50 or more deaths during the 2 years. Frequencies and rates are presented for the civilian workforce only, because denominator data were not available for military personnel.

Results. A total of 1,964 work-related injury deaths occurred in the construction industry in the United States during 1990 to 1991. Construction has an average annual fatality rate of 13.2 deaths per 100,000 workers. Occupations with 100 or more deaths during the 2 years are construction laborers (463 deaths), construction supervisors (161), carpenters (153), operating engineers (146), electricians (103), and managers and administrators, n.e.c. (100). Fatalities from these six occupations accounted for 57.3% of fatalities in the construction industry. Annual fatality rates by occupation were presented and there were 22 occupations which have higher annual fatality rates than the average of 13.2 per 100,000 workers for the entire construction industry. The six occupations with the highest annual fatality rates were electrical power installers and repairers (84.6 deaths per 100,000 workers); structural metal workers (74.7); operating engineers (47.7); engineering technicians, n.e.c. (44.8); drillers, earth (40.7); and construction laborers (33.3). Operating engineers and construction laborers were the occupations with both a high annual fatality rate and a large number of injury deaths. The leading cause of death varied among occupations. Falls were the leading cause of death for construction laborers; construction supervisors; carpenters; managers and administrators, n.e.c.; roofers; structural metal workers; construction and maintenance painters; and plumbers, pipe fitters, and steamfitters. Motor vehicle crashes were the leading cause of death for truck drivers and heavy construction trades, n.e.c. Machines were the leading cause of death for operating engineers. Electrocutions were the leading cause of death for electricians. Findings from this study are consistent with previous studies and underscore the urgent need for prevention measures for work-related fatalities among construction workers. Information on fatality risk by occupation and by cause of death could be useful for planning preventive strategies in the construction industry.

Preventing Injuries and Fatalities in Highway Construction Work Zones—Melius J, Kojola W, Hoffner K, Lapping K, Blacklow B

With support from the United States Department of Transportation, the Laborers' Health and Safety Fund of North America (LHSFNA) has been conducting a project to prevent injuries and fatalities among highway construction workers. Surveillance data indicated that these workers have a fatality rate twice as

high as that for the overall construction industry. The first phase of this study focused on the analysis of existing surveillance data on injuries and fatalities (including data from several highway contractors) to identify factors within the work zone contributing to fatalities and injuries among these workers. With assistance from a technical advisory group that included contractors, union members, and safety professionals, interventions to prevent these problems were identified and prioritized. These interventions ranged from better training programs to improved technology to prevent construction vehicle accidents. Currently, the LHSFNA is working with several academic institutions and other groups to evaluate or demonstrate several of these intervention approaches. These evaluation and demonstration projects should be completed by the Fall of 1997. Results from the initial surveillance study will be presented along with an overview of the intervention projects.

Machinery-related Fatalities in the U.S. Construction Industry, 1980-1992—Pratt SG, Kisner SM, Moore PH

The National Traumatic Occupational Fatalities (NTOF) surveillance system identified machinery-related incidents as the fourth leading cause of traumatic occupational fatalities in the U.S. construction industry between 1980 and 1992, resulting in 1,901 deaths and 2.13 deaths per 100,000 workers. All but 22 of the victims were males. Males had nearly eight times the fatality rate observed among females (2.3 vs. 0.29). The fatality rate in the Northeast census region, 1.29, was considerably lower than the rates in other regions, which ranged from 2.05 to 2.37. Overall, fatality rates declined 50% over the study period.

Workers in three occupation divisions—precision production, craft, and repair; transportation and material moving; and handlers, equipment cleaners, helpers, and laborers—had both the highest frequency and rate of fatalities. Cranes, excavating machinery, and tractors were the machines most frequently involved. During the study period, fatality rates for tractors and cranes declined 71% and 67%, respectively, while rates for excavating machinery declined only 12%. The most common incident types were: struck by a mobile machine; overturn; and struck by a boom.

Further delineation of groups at highest risk for machinery-related injuries is complicated by a lack of data on exposure to machinery, since exposure is clearly not equivalent across all occupational groups within the construction industry. The findings suggest that injury prevention programs should focus not only on machine operators, but on those who work on foot around machines. Translation of regulations into “plain English,” providing incentives for safe work practices, and addressing safety in project planning stages can also help to reduce machinery-related deaths in construction.

Session 2: Manual Material Handling

Manual Materials Handling Research: What We Should Know—Ayoub MM, Dempsey P

For over four decades, individuals from various disciplines have extensively researched the tasks comprising manual material handling (MMH): lifting, lowering, pushing, pulling, carrying and holding. Various criteria for defining acceptable task demands have been developed from the principles of biomechanics, physiology and psychophysics. Although significant bodies of literature exist

on each class of these criteria, there are still several areas which need to be further examined. The validity of several of these criteria is unknown or in question, primarily due to a lack of epidemiological verification.

This presentation provides a critical review of MMH criteria, the conflicts between these criteria, and the shortcomings of such criteria. The presentation will also provide a set of areas needing further examination and the research needs in the areas of biomechanics, physiology and psychophysics to assist in the refinement of these criteria. Finally, the presentation addresses the validity issue for these criteria.

Risk Factors of Muscle Injury and Falls Related to Load Handling Technique—Oddsson LIE

The main goal of the postural control system is to maintain stability in all situations and during all tasks that are performed. An external perturbation of posture triggers specific automatic responses which act to restore equilibrium. Few studies have investigated the interaction between automatic postural responses and voluntary movements. It has been hypothesized that certain combinations of voluntary movement and postural perturbation, such as a slip or a trip, may cause a conflict between postural and voluntary motor commands simultaneously requiring different functions of the same muscle/muscle group. It is further suggested that this conflict increases the risk of direct tissue injury and/or a fall. The occurrence of conflicts between motor commands is probably common during different occupational activities such as walking, lifting or carrying loads as well as during reaching for or pushing and pulling objects. An unexpected slip or trip that coincides with such an ongoing voluntary activity would have the potential to cause a motor command conflict. However, most of these situations will not lead to an injury. Nevertheless, the occurrence of a motor command conflict may still represent an injury prone situation and the margin of safety, before an injury occurs, is likely decreased. The current presentation will report findings that suggest the presence of a motor command conflict in the lumbar back muscles of subjects performing a lifting motion while being perturbed on a balance platform. A series of experiments were conducted where subjects were perturbed randomly at the feet in an anterior-posterior direction during vertical lifting of a 20 kg load. Subjects stood on a specially designed moving platform (BALDER, BALance DisturbER) programmed to accelerate (9.81 m/s^2) and then decelerate (9.81 m/s^2) over a distance of 0.11 m. Kinematic information was obtained from a video based motion analysis system (ARIEL, APAS). Muscle activity was recorded from soleus, tibialis anterior, anterior deltoideus and erector spinae (ES). Posterior platform perturbation triggered a hip strategy by the subject which resulted in a sudden cessation of activity in the ES muscle. In this phase of the movement, the task of lifting the load and supporting the trunk would require the ES muscle to be continuously active. However, instead there was an interruption of the lifting motion followed by a brief sudden trunk flexion. The trunk flexion coincided with an extended period of rapid changes in activation level of the ES muscle suggesting that the muscle was activated in a lengthening contraction to brake the trunk flexion movement. This effect was not seen during anterior platform perturbations. The results support the hypothesis that certain combinations of voluntary movement and postural perturbation elicit a conflict between motor commands simultaneously trying to access the same muscle group.

Evaluation of the Effect on Spinal Curvature of Various Lifting Regimens and Recovery Techniques—Evers CT

One of the most important aspects of any biomechanical research is the ability to measure the attributes of the body structure under investigation. In the field of industrial ergonomics and biomechanics, the back is a major area of concern, as back injuries account for a large percentage of both the injuries and cost of work accidents. Researchers have determined that there is a relationship between heavy work loads and back pain. Analysis methods used in many of these studies are not practical for use in most settings due to their sophisticated and invasive nature. Changes in the spine are considered a useful indicator for evaluating the effects of loading on the body. One method currently in use, the stadiometer, provides inferential data regarding spinal geometry by measuring stature. Another method directly measures the contour of the back to approximate the curvature of the spine. The proposed research will utilize the latter technique to accomplish the purpose of the research, which is to evaluate the response of spinal curvature to different combinations of workload and recovery method. This is a new area of research in industrial ergonomics. Findings of this research will expand our understanding of the spinal mechanics involved in lifting tasks, and may be used to develop recommendations for reducing the accumulated stress in the back as a result of workloads. The actual data collection will be done in June - July, 1997. In one test run using a 25 pound lift twice a minute in a task complying with the 1991 NIOSH Lifting Guidelines, an increase in the lumbar curvature in excess of 1 cm was observed after two hours. Following a 30 minute recovery period, this shift had disappeared and the lumbar arch was at its prelifting configuration. In the same trial, a decrease in spinal height of 2.2 mm was observed after the two hour lifting period. Following the recovery period, half of that decrease had been recovered. It is expected that similar results will be observed in the actual study.

EMG Analysis of Fatigue During Repetitive Work—Roy S., Bonato P, Knaflitz M

Over the past decade, the analysis of the surface electromyographic (SEMG) signal has been shown to be effective in objectively quantifying muscle impairments associated with sustained work. Application of the technique has been particularly successful for low back pain syndromes. The approach is based on indices of muscle fatigue derived by measuring the compression of the frequency content of the SEMG signal towards lower frequencies as the muscle accumulates metabolites. A primary limitation to this technique is that the quantification procedure for spectral analysis assumes signal stationarity. This pre-condition can only be satisfied by recording the SEMG signal during isometric, constant-force contractions. This is a serious limitation to the technique since many dynamic activities are commonly associated with work-related injuries. Fortunately, recent developments in the field of signal processing have produced methods of time-frequency (TF) analysis that are able to extract spectral information from nonstationary signals. Preliminary work has demonstrated that specific transforms belonging to the Cohen Class appear robust enough to derive spectral indices of fatigue from non-stationary SEMG signals recorded during cyclical dynamic contractions. In this paper we present the use of this procedure to measure localized paraspinal muscle fatigue during the repetitive lifting and lowering of a box. Time-dependent changes in SEMG spectral parameters, indicating the distribution of fatigue among superficial paraspinal muscles, were measured and com-

pared to the results obtained during a static isometric task at the same load.

The weight of the box, duration of the exercise, and frequency of the lift were specified according to safety guidelines of the National Institute for Occupational Safety and Health. Data were collected from eight subjects (five males and three females; mean age 26 ± 4 yrs) and analyzed by considering the TF representation of SEMG bursts sampled during the exercise. The contour plots of the TF distribution derived from two SEMG bursts recorded at the beginning ($n = 1$ s) and the end ($n=5$ min) of the lifting exercise clearly demonstrated the compression of the frequency components toward the lower end of the spectrum, thereby indicating the presence of fatigue. The relative amount of fatigue at the different electrode sites during the static vs. dynamic tests were qualitatively different indicating that fatigue was task-dependent and that we cannot generalize results obtained during static conditions to dynamic conditions. Furthermore, we observed that the SEMG signal recorded during dynamic contractions was also affected by factors not related to muscle fatigue. Namely, within each SEMG burst, changes in the exerted force, muscle length, and displacement between the muscle active fibers and the electrodes result in variations of the frequency content of the SEMG signal. As a result, we identified two separate nonstationary components in the SEMG signal collected during the dynamic exercise: 1) a within-burst nonstationarity related mainly to the biomechanics of the exercise (namely to variations of the exerted force as well as to the movement of the body segments which causes changes of the muscle length and a displacement between the active muscle fibers and the electrodes); and 2) a between-burst nonstationarity related to the gradual compression of the spectrum to lower frequencies as metabolites accumulate at the sarcolemma. These observations suggested that future studies focus on studying the effects of fatigue during cyclic dynamic tasks that have been implicated in repetitive use disorders.

Session 3: Human and Economic Costs of Occupational Injuries: Research on the Frontiers

The Human Costs of Occupational Injuries —Strunin L

This study uses ethnographic interviews to increase understanding of the experiences of workers with back injuries, including the impact on their relationship to their pre-injury job and employer, their post-injury employment, their interactions with the workers' compensation system, medical care providers, and lawyers, and their perceptions of fairness in the process. The study is being carried out in two states, Wisconsin and Florida, among 400 workers of different racial and/or ethnic backgrounds from different industries and occupations, and different workers' compensation systems. The interviews allow us to learn how workers perceive their injuries and how they experience components of the occupational injury systems that ultimately affect both the personal and social costs of occupational injuries. The data presented will focus on respondent-identified constructs about impacts of the injury on employment, family, and related health issues.

Integrating Results from Quantitative and Qualitative Studies of Workers with Soft Tissue Injuries—Miller T, Waehrer G, Leigh P

This paper describes the use of qualitative research to understand the effect of soft tissue injury on workers. We note the importance

of relations with the workplace in the experience of disability. We show how questions developed based on the qualitative results were used in a longitudinal study and proved to be important prognostic indicators for the injured workers. Qualitative research, although common in the social sciences, is rarely used in epidemiology. Fundamental differences in the underlying research paradigms, methods of inquiry, and rules of evidence in qualitative research and epidemiology pose challenges to the integration of these two genres of research. However, these same differences make the combination of methodologies a particularly powerful approach to the investigation of occupational injury problems, especially when applied to those with strong social or psychosocial components.

This is illustrated through an examination of the application of findings from a qualitative study of the experience of work-related back problems to an epidemiologic study of occupational musculoskeletal injuries. Injured workers' and key informants' verbatim interview data were analyzed using methods of grounded theory. Critical social dimensions of their experience were identified which appeared to influence recovery and return to work; in particular, problems of legitimacy and vulnerability in the workplace appeared central to the workers' experiences of injury and disability. Measurement constructs were subsequently developed and a series of closed-ended questions devised for inclusion in two prognostic cohort studies to enable the statistical testing of hypotheses which emerged from the qualitative research data. The questions were used in the Early Claimant Cohort Study, a prognostic cohort study of over 1800 injured workers. Workers were interviewed when they submitted Workers' Compensation claims, and at several other times for up to one year after injury. The time on benefits for up to one year after injury was determined from records. Using factor analysis we have confirmed the existence of two independent constructs: legitimacy and job vulnerability. The prognostic significance of these variables and their demographic correlates have also been examined. The results of these analyses indicate that the constructs are important in prognosis, but also highlight the need for more questionnaire development in this area.

Occupational Injury Costs Per Employee: Pinpointing the Risks —Shannon H

Objectives: 1. To estimate the medical and work loss costs of lost-workday occupational injuries reported to the Bureau of Labor Statistics (BLS). 2. To determine which occupations, industries, sources, events, age groups, and gender are associated with the highest costs per employee.

Methods: Work Loss Costs. BLS annual survey data show work days lost through a fixed date. Therefore, durations are censored for some cases. By major injury grouping, we built and applied non-linear regression models to estimate the full duration for censored cases in the 1993 annual survey. This was a massive modeling effort. It corrected for heterogeneity in the data and accounted for the existence of permanently and totally disabling injuries.

Once work-loss durations were available for all cases, we developed algorithms to compute lost wages. One approach used wages by occupation, industry, sex, and age group from the Current Population Survey. A problem with this approach is that an executive's injury can be weighted much more heavily than a production worker's, obscuring where the injury problems lie. A second, more

egalitarian approach used an average daily wage loss. The second approach facilitates injury risk comparisons between groups, but does not accurately depict employer or societal costs.

The work loss costs were supplemented by fringe benefit costs and by household work loss costs. Household work loss was estimated from work loss duration, data showing workers typically return to housework 10% sooner than wage work (but possibly trading for less demanding tasks), and studies of the value of housework.

Medical Costs. Medical costs by diagnosis were derived separately by injury diagnosis for hospital-admitted and non-admitted cases. Diagnosis-specific costs for admitted cases came from national average lengths of stay for cases covered by Workers Compensation (from 1987-1992 National Hospital Discharge Survey data) and costs per hospital day from states where cost control regulatory agencies force hospitals to accurately report these costs. Post-discharge costs in the acute care phase came from 1987 National Medical Expenditure Survey (NMES) data. Longer-term costs came National Council on Compensation Insurance Detailed Claims Information (DCI) data.

For non-admitted cases, costs per visit came from Civilian Health and Medical Program of the Uniformed Services (CHAMPUS) data. NMES described short-term visits per case and DCI described long-term costs.

1987-1992 National Health Interview Survey data were used to compute the number of medically treated cases without work loss from the BLS lost work-day case counts. Data scarcity forced us to perform these computations for broad diagnosis groupings.

Results. The analysis is in process. The data set lets us rank costs per employee by occupation, industry, source (e.g., a machine), event (e.g., a fall), body region, diagnosis, age group, and gender.

Session 4: Work Organization

Encouraging worker participation in safety programs: A selected review of research findings—Peters RH

Various strategies have been used to encourage employee participation in safety programs. The intent of this presentation is to provide guidance to safety professionals concerning the use of three techniques for encouraging employees to participate in their safety program: (1) employee surveys, (2) incentives, and (3) fear communications. Each strategy is briefly described and a summary of the empirical evidence concerning its effectiveness and limitations is given. Some recommendations are made concerning the use of these strategies.

Management practices affecting safety: An overview of coal industry research findings—Peters RH

This presentation focuses primarily on summarizing the past 20 years of research on management practices affecting underground coal miners' safety. Three factors have consistently been found to account for differences in mine safety performance across multiple research studies involving different samples of miners, different research methods, and different researchers. The factors are: (1)

the extent to which workers perceive that upper management is concerned about their welfare; (2) the extent to which management actively involves the work force in identifying safety problems and defining solutions; and (3) the favorableness of management-labor relations. The findings and implications of this research are discussed.

Reducing Accident Rates with Organizational Performance Management—Saarela KL

Safety professionals know a lot of safety and health, but do they know enough on how to achieve a change in practice. This difficult question is considered here on the basis of two intervention studies which were carried out in the shipbuilding industry and in the metal product industry. The goal of both projects was to launch an improvement process leading to a better work environment and safety, as well as to more efficient production. The cooperation partners represented industries in which the accident rate is above the national average in Finland. The action research approach combining research and practice and organizational performance management was utilized in the studies. The project at the shipyard was started in three departments at the beginning of 1995. In 1996 when the project was reported, it involved more than 10 departments (over 900 employees). The project in the metal product factory involved one department (about 200 employees) and was carried out in 1996. In the beginning of the projects, a questionnaire survey provided the personnel the opportunity to participate, to report problems they had identified, and to make suggestions for improvements. Local small groups with managers, supervisors and workers as members arranged regular meetings and followed a systematic model consisting of identification of problems, setting goals, solving problems, implementing changes, monitoring the results and providing feedback. In connection with the projects, everybody working in the intervention area participated in a two-hour training and development seminar. The questionnaire survey was repeated in order to get evaluative information. The effects of the interventions on accident rates were also investigated. The overall accident rate of the shipyard decreased by 56 % during the two year period (the goal was 25 %). According to the questionnaire survey, almost all the workers in the departments with the best results agreed that housekeeping had improved, work was progressing better, hazardous situations had decreased, cooperation had improved, new working practices had been learnt, and job satisfaction had improved. Over 70 % of the workers in these departments reported that it was easy to achieve improvements in their department; this reflected the innovative organization culture. Despite some differences between the departments, some improvements had been achieved in all departments participating in the project. In the metal product factory, the accident rate was reduced by 45 % during the one year period. In addition, improvement was noted, e.g. in delivery reliability, throughput time, productivity and profit. The department was interested in continuing with more demanding development tasks, and a new project was started this year in cooperation with the Finnish Institute of Occupational Health.

The Relationship Between Safety Climate and Injury/ Exposure in an Acute Care Hospital—Gershon RRM, Karkashian C, Martin LS, Grosch J, Murphy L

Introduction. We have previously identified organizational commitment to safety (i.e., "safety climate") as an important correlate

to safe work practices within the hospital workplace. To further advance our understanding of the complex relationship between safety climate and safe work practices and to clarify the role safety climate plays with respect to workplace injuries, such as needlestick injuries, we conducted a cross-sectional survey of employees at a large, 1000 bed, tertiary care hospital.

Methods. A questionnaire was designed to assess and characterize specific aspects of safety climate and to determine the relationship, if any, between these aspects and injury rates among hospital-based health care workers. The resulting five-page questionnaire was psychometrically analyzed and validated. Employee perception of safety climate was measured using a fifty-item safety climate scale, which factored into three distinct constructs: (1) facility-wide safety climate, (2) departmental-based safety climate, and (3) environmental safety climate. The questionnaire also contained items on injuries employees had experienced within the previous six months and these were further subdivided into categories of injuries and exposures, including exposures to bloodborne pathogens. Employees' compliance with safe work practices was measured using a 13 item compliance scale, and the questionnaires also included standard sociodemographic items. Most responses were based upon a five-point Likert scale (from strongly disagree to strongly agree). The confidential self-administered questionnaires were sent to a stratified random sample of clinical health care workers (i.e., those with direct patient or patient specimen contact) employed at a large, regional medical center.

Results. Responses were obtained from over 750 employees (60% response rate). Eighty-five percent of the respondents were female, the median age was 37 years, and the median tenure was 4.5 years. A total of 186 injuries (which occurred within the previous six months) were reported by 116 respondents. The respondents also reported 330 bloodborne pathogens exposures; 53 respondents reported a total of 74 needlesticks, 81 respondents reported 97 splashes to the mucosa, 52 respondents reported 81 cuts with sharp objects and 27 respondents reported 107 contacts with open wounds. Ninety-three (42%) of these exposures involved blood from a patient known to be infected with the human immunodeficiency virus and/or hepatitis B virus. Injuries were found to be highly correlated with two out of the three safety climate constructs. For example, low rates of injuries/exposures were correlated with strong facility-wide safety climate ($p < .01$) and departmental safety climate ($p < .001$). Employees who perceived a strong safety climate were significantly less likely to report workplace injuries. Safety climate was also significantly associated with high levels of self-reported compliance with safe work practices, and this was the case for all three safety climate constructs ($p < .001$).

Conclusions. Two safety climate constructs (facility-wide and departmental-based) were found to be significantly correlated with injuries and exposures; employees who perceived a strong safety climate at work were significantly less likely to report workplace injuries and exposures. Since these data are cross-sectional, we cannot determine causality—i.e., employees with fewer injuries may perceive their workplace to be safer, and this can only be determined from prospective studies. Nevertheless, these results inform us and help to identify the important determinants of safety climate. This will help us to appropriately focus our resources in our efforts to minimize the risk of injury/exposure among hospital-based health care workers.

Session 5: Injury Risk Assessment

Some Methodological Concerns in the Development of Predictive Models: Examples From Discriminant Analysis—Clancy EA

Multivariate parametric modeling is frequently used to develop predictive relationships between exposures (inputs) and the risk/occurrence of injury and illness (outcomes). Accurate predictive models can be used to suggest interventions which can minimize illness and injury. Perhaps due to the high cost of measuring particular exposures or to the sparsity of many adverse outcomes (most adverse outcomes, including certain traumatic injuries, are relatively rare events for the individual employment establishment), modeling studies in the health and safety literature frequently lack an independent test sample for evaluating predictive model performance. Rather, these studies report only the resubstitution accuracy - the accuracy which is realized when the model is evaluated on the same sample that was used to generate the model coefficients. Unfortunately, it is well established that the resubstitution accuracy is optimistically biased, that is, it typically provides an inflated estimate of the predictive accuracy of the developed model. For small data sets (small relative to the number of recorded exposures and/or exposures included in the model), this optimistic bias can be substantial. Furthermore, small data sets may lead to selection of an entirely spurious set of exposures.

To elucidate this issue, a Monte Carlo simulation study was conducted using the classification modeling technique of discriminant analysis. Random data containing no true classification power (denoted the “Nil Model”) were generated, then analyzed using discriminant analysis. For the case of two outcome groups, the true accuracy of the Nil Model is 50% (i.e., no better than flipping a fair coin). For conditions similar to those in the literature, the random data “reported” highly accurate classification performance - results as high as 100%. These “reports” represent the bias artifact of resubstitution accuracy. Factors influencing the extent of the bias were studied. It was found that the resubstitution bias is reduced if: sample size is increased, the number of candidate exposures is decreased, the number of selected exposures is decreased, and the proportion of samples from each outcome group is equalized. These simulation studies indicate that reporting of the resubstitution accuracy alone can be problematic. The resubstitution accuracy can be made arbitrarily large, regardless of the true predictive accuracy of the model.

The most common approach to rectifying this situation is the use of a train-test methodology in which the collected subject data are separated into non-overlapping, independent training and testing sets. The model is trained (i.e., the model coefficients are computed) on the training set, then tested on the test set. The performance achieved on an adequately sized test set is considered a good estimate of the true predictive model performance. It is suggested that all research reports which develop parametric models should either (1) train the model on one data set, but report as the performance metric the accuracy achieved on an independent, adequately-sized test data set, or (2) demonstrate that the magnitude of the resubstitution bias is minimal.

Quantifying and Aiding Laymen Understanding of Risks—Cohen BL

The average layman has great difficulty in understanding the difference between a risk of 0.0001 and 0.000001, but expressing

these in terms of loss-of-life-expectancy, LLE, makes it much easier. The difference between LLE = 1 day or 100 days is relevant to the layman's everyday experience and is therefore very understandable. The LLE approach has the weakness of ignoring non-fatal injuries, but it has a great advantage for quantitative treatment—dead bodies are easy to identify and count, whereas morbidity has a wide spectrum of seriousness and is subject to wide variations in perception of suffering. It may be useful to introduce a multiplier on LLE to account for morbidity, since this multiplier would normally be not much larger than unity, but it would be very difficult to reach consensus on these multipliers.

Numerous examples of LLE will be presented. Some of these LLE are many years, like alcoholism, poverty, smoking, poor social connections, and overweight, while others are less than one day, like carcinogens in peanut butter or charcoal broiling, or living near a nuclear power plant, but the public does not perceive this thousandfold difference—this is a problem in media coverage. There are also wide variations in LLE due to occupational risks between different industries, and between different subgroups of workers within industries; many examples will be given. Occupational diseases are generally much more important contributors to LLE than accidents. Some approaches to estimating LLE due to occupational diseases will be discussed.

Burden Due to Occupational Hazard—Murray CJL, Acharya AK

The Global Burden of Disease Study was initiated in 1992 at the request the World Bank and has been undertaken with full collaboration and participation of the World Health Organization. Preliminary results were used in the World Bank's World Development Report 1993: Investing in Health (1) and published by WHO in 1994 (2). The GBD was designed to address three primary goals: to infuse information on non-fatal health outcomes into debates on international health policy, which are all too often focused on mortality; to develop epidemiological assessments for major health conditions unbiased by advocacy groups; and to quantify the burden of disease using a measure that could also be used for cost-effectiveness analysis. Four specific objectives were established: (i) to develop internally consistent estimates of mortality for 107 major causes of death by age and sex for the world, divided into eight geographic regions; (ii) to develop internally consistent estimates of the incidence, prevalence, duration and case-fatality for 483 disabling sequelae of these 107 causes of disease and injury by age, sex and region; (iii) to estimate the fraction of mortality and disability attributable to ten major risk factors by age, sex and region; and (iv) to develop various projection scenarios of mortality and disability by cause, age, sex and region.

Deaths from occupational injuries and occupational diseases were evaluated as part of the risk factor assessment of the GBD. The GBD study results were based on inferences drawn from data from reporting systems in the United States, Canada, Australia, Sweden, Denmark, the United Kingdom, Switzerland, Luxembourg, Hungary, Mexico and China (selected causes only). Occupational diseases accounted for 1.0 million deaths and there were an estimated 100 thousand occupational injury deaths in 1990. The distribution of deaths by region is shown in the following table. In this study, we have also estimated the disability attributable to occupational injury. The combination of premature mortality and disability is measured in terms of Disability-Adjusted Life Years (DALYs).

Deaths and DALYs from Occupational Injuries
(in thousands)

<i>Region</i>	<i>Deaths</i>	<i>DALYs</i>
EME	14	540
FSE	10	405
IND	15	655
CHI	20	1,039
OAI	12	566
SSA	10	550
LAC	9	429
MEC	9	461
World	99	4,645

A United States burden of disease study which will include an analysis of occupational injuries and diseases is underway.

Session 6: Nonfatal Injuries in Construction

Construction Injury Rates May Exceed National Estimates: Evidence from the Construction of Denver International Airport (DIA)—Glazner JE, Borgerding JA, Lowery JT, Bondy J, Kreiss K

Aim. To describe occupational injury rates and workers' compensation (WC) payment rates on a major construction project.

Background. Most injury rate estimates rely on survey data (Bureau of Labor Statistics (BLS)), analysis of WC claims, emergency room surveillance and proportionate mortality studies. These may suffer from underreporting and/or imprecise estimates of the number of workers at risk. Construction of DIA, with 31 million person hours on 2,843 contracts held by 769 contractors, provided a unique opportunity to describe the magnitude of injury on a major construction project.

Methods. The airport owner implemented a project-wide WC insurance plan for all on-site workers involved in airport construction. All claims were recorded in a centralized database, as was payroll according to job classification. Injuries were treated at an on-site clinic operated by a designated medical provider; claims were generated whenever treatment was rendered. Using a computer file with all claims, payroll by contract (allowing calculation of hours at risk), and company characteristics, we calculated injury and payment rates by construction sector, company size, and year.

Results. DIA's total injury rates were over twice BLS's rates for the construction industry for each year of construction. Lost-work-time (LWT) injury rates were more comparable, but DIA's were slightly higher. The order of injury rates by SIC code was the same in both data sets, with SIC 17 (special trades) having the highest rates. Total injury rates for DIA's small contractors (1-19 employees) were three times BLS's reported rates and at least twice BLS's rates for all other company size categories. Injury rates declined significantly after the first year of DIA construction, coincident with a several-fold increase in project safety personnel. DIA's total WC payment rate of \$7.06 per \$100 payroll was 11 percent higher than expected loss rates reported by the National Council on Compensation Insurance, in contrast to the two-fold differential between injury occurrence at DIA and BLS survey data.

Conclusion. Complete reporting, facilitated by the existence of a single WC plan, an on-site medical clinic and designated medical

providers, produced injury rates significantly higher than previously reported. The relatively small difference between payment rates and expected loss rates suggests that underreporting is concentrated in the area of minor injuries, which we found to be associated at the contract level with major injuries. Our results suggest that underreporting of WC claims occurs and may result in sizable underestimates of the burden of injury in construction.

Risk Factors for Injury Among Construction Workers on the Denver International Airport (DIA) Project—Lowery JT, Borgerding JA, Zhen B, Glazner JE, Bondy J, Kreiss K

Aim. To identify risk factors for work-related injury on the Denver International Airport construction project, which generated over 31 million person-hours, employing 32,000 workers from 769 companies to complete 2,843 contracts.

Methods. We obtained workers' compensation claims data from an administrative database established under the project's owner-controlled insurance plan, which covered all on-site employees and provided on-site medical care through designated providers. We calculated injury rates by contract and over contract strata of interest by linking claims data with employee demographic information, company and contract characteristics, and contract payroll. We determined that injury rates among contracts held by the same company were independent using generalized estimating equations, enabling us to examine contract-specific factors in relation to total injuries, lost-work-time (LWT) injuries, and non-LWT injuries in Poisson regression models. To control for inherent risk of work in the model, we included expected loss rates (ELRs), which we calculated for contracts using Colorado-specific ELRs provided by the National Council on Compensation Insurance for each job classification. We used logistic regression to determine the association between LWT and non-LWT injuries on a contract level, controlling for person-hours at risk and ELRs.

Results. Injury rates were highest during the first year of construction, at the beginning of contracts and among older workers. Risk for total and non-LWT injuries was elevated for building construction contracts, contracts for special trades companies (SIC 17), contracts with payroll over \$1 million and those with overtime payroll greater than 20 percent. Risk for LWT injuries, on the other hand, was increased for site development contracts and contracts starting in the first year of construction. Large companies (250+ employees) had significantly lower risk for all injuries.

Contracts experiencing one or more minor injuries were four times as likely to have at least one major injury [OR=4.0, 95%CI(2.9,5.5)].

Conclusion. Our finding of increased risk of LWT injury for contracts starting in the first year of the project suggests that enhancement of the project's safety infrastructure during the second year of construction was effective in reducing serious work-site injuries. The absence of correlation between injury rates among contracts belonging to the same company suggests that targeting of safety resources at the level of the contract may be an effective approach to injury prevention. Interventions focused on contracts with considerable overtime work, contracts of special trades companies (SIC 17), and those belonging to small and mid-sized companies may yield reductions in injury rates. Furthermore, efforts to provide adequate site-specific training to workers new to a construction site or new to a contract may also reduce injury burden on large construction sites. The joint occurrence of minor and major

injuries on a contract level suggests that surveillance of minor injuries may be useful in identifying opportunities for prevention of major injuries.

Trade-specific Injury Rates at a Large Construction Project—Welch LS, Hunting K, Aleali R

Construction as an industry has a high injury rate, as documented in annual BLS surveys and other data sources. CFOI contains trade-specific data that allows a determination of rates for fatal injuries for specific trades, but trade-specific data is not readily available for non-fatal injuries. Surveillance data is collected in order to design, implement and evaluate prevention programs. Trade-specific surveillance data for construction workers is necessary if we are to understand the causes of injuries, and find ways to prevent them.

We have monitored injuries from a large construction project from 1990-1997. All injuries were treated at the George Washington University emergency department, and data on each injury was abstracted. We have obtained hours worked through the project by contractor and developed trade specific rates for this project. We will present these trade specific rates, discuss how these data differ from BLS data, and compare our rates to trade specific data collected on other large construction sites. We will also present a model for implementing trade specific surveillance on other construction sites.

Occupational Injury and Fatality Patterns of Females Employed in the Construction Industry: Kentucky, 1991-95—Mays J, Kidd P, Struttman T

Purpose. In Kentucky, almost 10% (n=7250) of the construction industry workforce is female. Recent studies have identified risks in the construction industry that are particular to females. However, epidemiologic studies of females employed in the construction industry are scarce. This study provides important epidemiologic information useful in targeting interventions for females employed in the construction industry.

Research Data. This investigation used data from the Kentucky Department of Workers Claims from 1991-95 to describe both the injury and fatality patterns of females employed in the construction industry in Kentucky. The data set contained information on sector of employment, age, gender, number of months employed, time on that particular job, body part injured, nature, extent, and cause of injury, and days of work lost.

Methods. The data were obtained electronically from the Kentucky Department of Workers Claims. Injury and fatality patterns of females are described and compared across several key stratification variables. Where appropriate, injury and fatality patterns of females are compared to males to determine differences in the characteristics of the injury or fatality. Analysis of variance and chi-square tests are used to test for statistical significance.

Results. Seven hundred and sixty-eight claims for females employed in the construction industry were filed with the Commonwealth of Kentucky's Department of Worker's Claims from 1991-1995. Less than 1 percent (n=4) of the 768 claims were fatalities, 0.1% (n=1) was a permanent total disability claim, 1.0% (n=8) was a permanent partial disability claim, 52.3% (n=402) were temporary disability claims, 43.6% (n=335) were lost time claims, and 2.3%

(n=18) were no lost time claims. The average number of days lost for females was 19.8 and did not differ significantly from males (18.0 days). The body region injured differed significantly between females and males (p<0.001) with females having a higher proportion of injuries to multiple body parts than males (17.8% vs. 10.3). Regarding nature of injury, females had a significantly higher proportion than males of contusions (11.8% versus 7.4%, p<0.001), carpal tunnel syndrome (2.3% versus 0.3%, p<0.001), and "all other cumulative injuries" (12.8% versus 1.7%, p<0.001). Most of the claims filed for females were in the special trades sector (43.0%) versus heavy construction (39.8%) or general contracting (17.2%). However, while 39.8% of claims filed by females were in heavy construction, only 23.9% of claims for males were in this sector (p<0.001). Specifically, 35.6% of all claims filed for females were for those employed in highway, street, and bridge construction (SIC = 1611, 1622) compared to only 17.7% for males (p<0.001). In addition, a significantly higher proportion of claims for females versus males reported trucks, cars, highway vehicles, or earth moving vehicles involved in road construction as the source of the injury (10.0% versus 6.3%, p<0.001).

Conclusion. These findings suggest that interventions designed to reduce the number and severity of occupational injuries and fatalities of females employed in the construction industry should be focused on the heavy construction industry, particularly road, highway, and bridge construction.

Injuries Among N.C. Residential Construction Workers, 1986-1994—Dement JM, Lipscomb H

All computerized workers' compensation claims for 7400 N.C. Homebuilders Association (NCHA) members and their subcontractors for the period 1986-1994 were obtained from their compensation insurance carrier. Average annual incidence density rates (cases/200,000 work hours) were calculated for all claims, claims involving medical costs or paid lost work time and by mechanism, nature and body part injured. Incidence density rates were calculated separately for each residential construction craft.

A total of 31,133 worker's compensation claims were filed by homebuilders during 1986-1994. Of these claims, 10,680 claims were for minor medical costs (less than \$2000) without lost work time beyond the date of injury. A total of 7199 claims involved paid lost work time which begins after the seventh day away from work in North Carolina. An additional 3543 claims involving medical costs of \$2000 or less and no paid lost time occurred. For the seven years studied, the following average rates of filing claims by claim type were observed.

	Cases/200,000 hrs	
Overall	Paid Lost Work Day	Medical or Lost Time
16.40	3.79	10.78

Twenty-six work related deaths occurred among residential construction workers during the seven years studied. Vehicle accidents (n=6) were observed to be the major known cause followed by falls (n=3), being struck by an object (n=3), electric shock (n=2), and contact with energy or chemicals (n=2).

Highest rates for cases involving medical costs or paid lost time by mechanism of injury were observed for being struck by an object (3.1), lifting/movement (1.97), falls from a different level (1.13), striking against an object (0.87) and falls on the same level (0.46).

Rates by mechanism of injury were highest for muscle strains (2.34), wounds/punctures (2.33), bruises/contusions (1.24), fractures/dislocations (0.98) and injuries to the eyes (0.81). Among medical cost or lost work time cases, body parts with highest injury rates (cases/200,000 hours) were back/shoulders (1.99), fingers (1.31), leg/knee (1.00), hand/wrist (1.00), foot/ankle (0.86) and eyes (0.82).

Injury rates were found to vary substantially among the residential construction trades. For more serious injuries involving medical costs or lost time, rates were highest for welders and cutters (28.1), insulators (24.3), roofers (19.4), and carpenters (15.3). The same general trends by trade were observed for cases involving paid lost time except that roofers were highest with a rate of 9.1 cases/200,000 hours followed by insulators (8.5), welders and cutters (5.8) and carpenters (5.8).

Rates of falls from a different level resulting in medical costs or lost time were highest for roofers (5.54), insulators (3.53), carpenters (2.05) and drywall installers (1.99). Falls from a different level resulted in a fracture/dislocation 36.8% of the time followed by bruises/contusions (22.7%), muscle strains (21.5%) and joint sprains (10.3%). Multiple serious injuries occurred with 1.3% of the falls from a different level. Body parts most frequently injured during due to falls from a different level were back/shoulders (25.0%), foot/ankle (18.5%), leg/knee (16.4%) and arm/elbow (11.1%).

Descriptive information for falls from a different level resulting in paid lost time during 1993-94 (N=219) were reviewed in order to better determine the causes and circumstances of injuries. Falls from a roof accounted for 25.4% of the cases followed by falls involving scaffolds (23.9%), ladders (20.6%) and falls from ceiling joists, floor joists or framing (14.8%).

Session 7: Ergonomics and Safety Assessment Methodology

A Review of Methods for Estimating the Amplitude of the Surface Electromyogram (EMG): A Window into Assessing Muscular Effort in Musculoskeletal Injuries—Clancy EA

The amplitude of the surface EMG provides a measure of muscular effort and has also been investigated as an indicator of muscle force. Applications which utilize EMG amplitude in the study of traumatic musculoskeletal injuries include investigations into the mechanisms of injuries (e.g., muscular activation patterns experienced during slipping, tripping and falling), studies of muscular exposures associated with injuries (e.g., muscular efforts and tensions coincident with lifting/lowering heavy objects), and physical therapy/rehabilitation (e.g., clinical assessment of muscular function). This presentation reviews typical methods used to estimate the EMG amplitude from the EMG waveform and describes recent/developing advances in EMG processing techniques.

Early investigators treated the EMG waveform as an amplitude modulated signal. The original amplitude estimator consisted of a full-wave rectifier (demodulator) followed by a resistor-capacitor (RC) low pass filter (smoother). Empirically, it was then found that the signal to noise ratio (SNR) of a third-order averaging filter provided a 44% improvement, and that a second-power demodulator was best. Mathematical models, representing EMG as band-limited Gaussian noise, found that second-power demodulation and

averaging, i.e. RMS processing, gives optimal amplitude estimation. Typical amplitude estimators in use today utilize one of the above processors, with RMS processing preferred.

Several investigators found that inclusion of a whitening filter (a filter whose output power spectrum is constant-valued when presented with the input signal) prior to demodulation improved estimator performance. Auto-regressive modeling of the EMG power spectrum was used to form whitening filters which doubled the probability of differentiating between four contraction levels. For contractions above 10% MVC, similar whitening filters improved the SNR by 63%. Whitening can also be achieved by reducing the outer edge spacing of a pair of rectangular bipolar electrodes. A few authors have found that the shape of the whitening filter should adapt as a function of the contraction level.

Dispersing multiple electrodes about a muscle may provide a broader, more complete, measure of the underlying electrophysiologic activity. Using four electrodes, an SNR improvement of 91% has been achieved. Four electrodes have been used to improve the probability of differentiating between four contraction levels by 40-70%. The combination of four electrodes and whitening via electrode geometry yielded a 176% SNR improvement. Eight whitened (auto-regressive technique), combined electrodes provided a 309% SNR improvement.

When the EMG amplitude varies throughout contraction, improved amplitude estimates can be achieved if the smoothing window length is tuned throughout the contraction. Adaptive window length processors have been implemented based on the EMG amplitude and its first derivative. When contraction levels changed rapidly or slowly, marked estimator performance improvement resulted.

Future EMG amplitude estimators should incorporate all of these improvements - adaptive whitening, multiple electrode combination and adaptive smoothing window length - into a robust processor. The improved amplitude estimator performance which results should provide more accurate assessment of muscular effort, muscular activation patterns, muscular tension and other related muscular function indicators of interest to occupational safety and health.

Assessment of a Cartographer's Workstation—Pentikis J

Office ergonomics has become an important workplace issue, however the problem of using a mouse almost exclusively to operate software has not received as much attention as other facets of office ergonomics, i.e. lighting or keyboards.

Cartographers working for the U.S. Army spend their entire workday in a seated position performing intensive input to their computers using a hand "mouse." The nature of the work has resulted in upper extremity injuries as well as a high rate of upper extremity and back discomfort levels.

The problems faced by cartographers is threefold. First, the mice provided to the cartographers placed their wrists in non-neutral postures and also placed mechanical stresses on the hand. Second, the tasks associated with the cartographers work activities require prolonged static postures of the upper extremity and back for the majority of the workday. Third, the workstations are not highly adjustable thereby forcing the cartographers to work in less than optimal postures.

Corrective actions included redesigning the mouse in order to place the wrists in a neutral posture, the mouse was shaped with rounded edges to reduce the mechanical stress placed on the hands, and the buttons on the mouse were rearranged and the force requirements lessened to avoid having the fingers stretch and use excessive force to operate the buttons on the mouse. Second, new chairs which are capable of being easily adjustable in height, seat pan angle, and back rest angle which also offer lumbar support are to be purchased. Third, the desks which are adjustable in height are to be replaced with desks that are adjustable in height and can also be tilted to move the desk surface closer to the cartographer. Finally, alternative tasks are being investigated to see if it is feasible to encourage the cartographers to move away from their seated workstation each hour.

Preventing Accidents Caused by Unrecognized Roof Beam Failures in Underground Stone Mines—Iannacchione AT, Prosser LJ, Oyler DC, Dolinar DR, Marshall TE, Compton CS

A safer environment for stone miners can be realized by enhancing the industry's ability to recognize and monitor hazardous ground conditions. This is necessary because 12 of the 14 underground stone miner fatalities in the last six years were caused by falls of roof or rib. Because the total underground miner population is less than 2,000, the fatality incident rate is greater than for miners working in underground coal mines. Despite society's demand for the resultant products of stone mining, i.e., highways, buildings, agriculture, water purification, etc., the public typically opposes the development of surface stone quarries. Thus underground stone mines are emerging as an alternative method for producing needed raw materials within the tolerance level of the general public.

One technique under development by NIOSH at the Pittsburgh Research Center aimed at reducing the safety risk to miners is a remote monitor to detect hazardous ground conditions. Existing mechanical roof monitoring devices installed in drill holes have experienced only limited use in underground stone mines. These monitors are generally single point extensometers which measure the overall separation of roof layers in the immediate roof. Hazardous levels of roof sag signal a high potential for roof failure. In some cases this information has been used to add roof support, remove roof rock, or danger off affected areas. Unfortunately, these instruments are difficult to read because of their location on the roof line, require a considerable number to accomplish full coverage, and require considerable experience to determine dangerous sag rates. A new generation Automated Roof Monitoring Safety System (ARMSS) developed by NIOSH improves on the existing methods for determining roof stability. This mechanical roof sag monitor includes the following features: 1) inexpensive (<\$150), 2) multiple anchor points [a many as six], 3) adaptable to standard data acquisition systems, 4) easy to install, and 5) remote monitoring capability. At a recent field site test the following issues were examined: 1) what are critical sag rates?, 2) how much sag occurs prior to a roof fall?, 3) at what locations in the roof does the failure occur?, 4) how often should monitors be read?, 5) where should monitors be placed within the entry?, 6) when should monitors be used?, and 7) how should the monitor data be analyzed? This research will provide recommendations/guidelines on these issues so that this technology can be used effectively and efficiently in an effort to improve the safety conditions for underground stone miners.

SCOPE: System for the Classification of Operator Performance Events—Kapp EA

Human error as a cause of accidents in the workplace has been an area of concentrated interest among safety practitioners and researchers since Heinrich's first edition of *Industrial Accident Prevention* in 1931.

The literature is widely divergent as to what percentage of occupational accidents can be attributed to human error, with some claiming 80-90% of all accidents are due to human error (Salminen and Tallberg, 1996) while others report percentages around 50% (van der Schaaf, 1992).

Regardless of the exact figure, human error is widely accepted as a major source of or contributing factor to accidents and injuries in the workplace.

There have been numerous approaches to investigating of human error including: examination of the psychological characteristics of the employee, physical characteristics of the workplace, and management and organizational characteristics of the organization.

Each approach has shed some light on the issue, but none alone has provided a complete and usable approach to analyzing human error in the workplace.

SCOPE (System for the Classification of Operator Performance Events) is a comprehensive tool for investigating workplace accidents caused by human errors. Synthesized from the research on Human Information Processing, Signal Detection Theory, Judgment and Decision Making, Organizational Design and Management, Work Physiology, and Ergonomics, SCOPE analyzes accidents to uncover the sources of the human error that caused the accident.

SCOPE uses a two phase approach for the analysis: Event Description, and Causal Factor Analysis.

Event Description involves the recording of all relevant facts concerning the accident. Causal Factor Analysis uses the event description to pinpoint the underlying workplace factors that produced the human error.

Causal Factor Analysis consists of three steps: (1) mapping of the cause and effect process that created the accident through creation of an Incident Production Tree; (2) classification of the operator errors involved in the accident through the Error Classification Flowchart; and (3) determination of the contributing factors in the workplace that produced the errors using the Workplace Factors Checklist.

Preliminary testing in the healthcare industry indicates that SCOPE has great promise for use in operational settings to determine the underlying causes of human errors in the workplace.

References: Salminen, S. and Tallberg, T. (1996). Human errors in fatal and serious occupational accidents in Finland. *Ergonomics*, 39(7). 980-988.

Van der Schaaf, T. (1992) *Near Miss Reporting in the Chemical Process Industry*. Eindhoven: Technical University of Eindhoven.

Concrete Shoring Systems Loads and Safe Design—Huston DR

This paper reports on a study that examines safety issues related to preventing the collapse of temporary support structures, called shoring, during the construction of buildings with reinforced concrete columns and floor slabs. The basic problem is that fresh concrete is quite weak and cannot support its own weight. As concrete cures, it grows stronger and is eventually able to carry its weight. It is during the pouring and curing stages that the structure is vulnerable to collapse and to cause injury and often death. Hadipriono and Wang (1986) reported on 85 such collapses that occurred during the previous 25 years. The main issue with preventing these collapses is to design and use the shoring systems to support the concrete properly. Unfortunately, there have been very few field measurements of the loads experienced by shores and the performance of shoring systems. The objective of this study is to measure the loads on shores as the buildings are being built and to use this information to evaluate the existing codes and to make recommendations for improved shoring design and use procedures. Loads have been measured in four buildings, three of which are low rise buildings of a couple stories each. The fourth building is a twenty-five story high-rise in Cambridge MA, known as the Museum Tower. The building is built with a new shoring system that allows rapid construction sequencing. Slab deflection measurements are taken on the building as well. The measured loads are compared with those predicted by computer models and by the ACI code. Preliminary results from the data indicate that there can be large variations in the loads on nominally identical shores, thermal effects are much larger than anticipated, and the average loads are close to those predicted by ACI. Certain recommendations are being formulated for the use of safer pouring sequences, the design loads for shores, and the use of electronic monitoring and hazardous condition alarm instrumentation.

Session 8: Social and Economic Impact of Occupational Injuries***Social and Economic Impact of Occupational Back and Upper Extremity Injuries: A Pilot study***—Pransky G, Benjamin K, Hill-Fotouhi C

We obtained a random, stratified sample of 405 individuals who had occupational upper extremity or low back injuries a year before a survey was mailed to them. The survey included information on demographics, employment, social and other factors, and multiple dimension of health-related quality of life, as well as economic and other consequences of injuries. The survey was the product of extensive validation and reliability testing, and incorporated previously-used questions as well as several new scales. We attained a follow-up rate of over 65% of those where addresses could be verified, with only 8% refusing to participate.

Results. Length of time out of work was directly associated with a number of adverse economic, functional, and psychological consequences. Employer accommodations were important in achieving early return to work, and were actually more strongly associated with prevention of re-injury than job modifications that were specifically designed to prevent recurrence. Although less than 10% never returned to work, persistent functional and symptomatic problems due to the injury were still present in most respondents. Time loss was also associated with negative employer responses. We conclude that immediate employer responses to work-related injuries

should include effective prevention activities, but that the nature of preventive activities should be examined more closely, as safety rules and other changes may not be effective in preventing reinjury. Work-related injuries in a typical population are associated with significant burden in terms of lost wages, psychological and social disruption, and persistent symptoms and functional deficits, despite returns to work.

National Costs of Occupational Injuries in 1992—Leigh JP

Objective. To estimate the annual incidence, the mortality and the direct and indirect costs associated with occupational injuries in the United States in 1992.

Design. Aggregation and analysis of national and large regional data sets collected by the Bureau of Labor Statistics, the National Council on Compensation Insurance, the National Center for Health Statistics, the Health Care Financing Agency, and other governmental bureaus and private firms.

Methods. To assess incidence and mortality of occupational injuries and illnesses, we reviewed data from national surveys. To assess costs we used the human capital method that decomposes costs into direct categories such as medical and insurance administration expenses as well as indirect categories such as lost earnings, lost home production and lost fringe benefits. Some cost estimates were drawn from the literature while others were generated within this study. Total costs were calculated by multiplying average costs by the number of injuries in each diagnostic category.

Results. Approximately 6,500 job-related injury deaths, and 13.2 million non-fatal injuries are estimated to occur annually in the civilian American workforce. The total direct (\$49 billion) plus indirect (\$96 billion) costs were estimated to be \$145 billion. Of the \$49 billion in direct costs, \$25.1 billion was spent on doctors, hospitals, drugs, nursing homes, and rehabilitation providers; \$5.7 and \$8.9 billion went to cover medical and indemnity insurance administration expenses; \$8.7 billion covered property damage; and \$0.8 billion paid for police and fire services. The \$96.2 billion of indirect costs can also be disaggregated: \$68 billion in wage losses; \$14 billion in fringe benefits; \$8 billion in home production losses; \$5.2 billion for workplace training; and \$0.3 for time delays. The estimates are likely to be low, because they ignore costs associated with pain and suffering as well as those of within-home care provided by family members, and because the numbers of occupational injuries are likely to be undercounted.

Conclusion. The costs of occupational injuries are high, in sharp contrast to the limited public attention and societal resources devoted to their prevention and amelioration. Occupational injuries are an insufficiently appreciated contributor to the total burden of health care costs in the United States.

Return to Work Following Traumatic Injury: A Prospective Study of the Effect of Trauma on Patients' Working Lives—Petersen JS, Morabito D, Boccillari A, Mackersie RC, Ochitill H

Victims of acute traumatic injuries are displaced from the labor force by an event exogenous to their usual occupational responsibilities. This displacement represents economic costs to individuals, their families, and society because of the temporary or permanent loss of productive activity. To date, little is known about the

impact of non-disabling injury on an individual's economic status. The purpose of this study was to estimate the economic impact of moderate traumatic injury on labor market activity, to define additional factors that may act to facilitate or inhibit return to work, and to better assess the need for program interventions that would facilitate recovery.

Patients and Methods: Patients were recruited on the basis of: 1) pre-injury employment, 2) absence of psychiatric history, 3) absence of neurologic or other permanently disabling injury. Data were collected prior to discharge and at 6 month follow up. Data included injury severity, pre- and post-injury wages/salary, working conditions, job satisfaction, qualification for transfer payment programs, pre-injury health status, and household wealth.

Summary Statistics. The average age of the patient population was 33 yrs (s.d. 11). The patients had a mean injury severity score of 12 (s.d. 9.3) and length of stay (days) of 6.3 (s.d. 4.8). Injuries incurred were as follows: upper ext. fx. (7), lower ext. fx. (24), pelvic/spine fx. (11), chest/abd. inj. (16).

Results. Sixty-one patients were recruited for the study with occupations evenly distributed between blue (n=31) and white collar (n=30) classes as defined by the Department of Labor. Prior to injury 82% of patients found their work a rewarding experience; 74% said they would continue working even if they did not need the money; and 61% felt their injury would impair their ability to return to work. At six month follow-up interval, 67% of subjects had not returned to work. The average annual salary of the patients was \$24,944 (s.d. \$15,014) while average lost earnings and working hours due to injury were \$10,165 and 796, respectively. Over one-third of the subjects reported that a family member took time off work to care for them. The average lost earnings of these family members was \$2,760. Factors that positively influenced return to work were job satisfaction and earnings, while negative factors were stressful working conditions, mental health status, and impending lawsuits related to the injury.

Conclusions. Moderate trauma results in potentially crippling economic disruption to individuals and their families and inflicts large aggregate costs to society. Low income households may be further marginalized by the effects of trauma due to substantial loss in patient and family earnings. Trauma patients "at-risk" for not returning to the labor force may be identified on the basis of post-injury economic and vocational factors. The aggregate costs to individuals and society reflected by this data suggests a need for, and the potential feasibility of, cost-effective programs that will facilitate return to work in this patient population.

Gaining an Economic View of Construction-Related Injury: Integrating Quantitative and Qualitative Data—Kidd P, Struttman T, Mays J, Parshall M

Economic factors influence both the safety decisions and safety performance of construction workers and owners of construction companies. The framework for intervention development used in this study is an inductively derived model linking stress, economics, and injury. To develop an intervention that integrates economic factors in a meaningful fashion for these individuals, it is necessary to understand from their point of view the decision making process used in assuming greater risk. For injury prevention efforts to be successful in the construction industry, owners/opera-

tors and workers must be presented with information depicting safety as economically advantageous to their companies and careers. Because no one data source is available to understand the multifaceted, complex relationships between economics and safety, integration of multiple data bases were used. In this presentation we will discuss briefly the intervention model and the data bases used in gaining an economic view of construction-related injury. Data bases integrated include: focus group sessions, case studies of fatal and minor injuries, interviews with chiropractors, a hospital trauma registry, state worker compensation files, and insurance policies and claims. The integration process used in combining qualitative and quantitative data will be discussed and illustrations provided.

Measuring the Injury Severity of Occupational Injuries—Gillen M, Faucett J, Beaumont J, McLoughlin JJE

Finding a measure that distinguishes well between the severity levels of less serious injuries such as those found in occupational settings has been problematic. In this study of 255 construction workers who sustained nonfatal falls at work, two measures of injury severity were used - the Injury Severity Score (ISS) and the disability section of the Stanford Health Assessment Questionnaire (HAQ), a functional limitation measure. It was hypothesized that the functional limitation measure would provide a more normal distribution of scores as compared to the ISS, which is a threat-to-life scale. As predicted, the ISS scores in this study were clustered toward the lower end of the scale with 112 injuries (43%) receiving a score of 1. The mean ISS was 3.2 (SD = 3.0; median = 2.0) on an ordinal scale from 1 to 75. The highest ISS was 22.

The HAQ originally was developed to evaluate functional limitations in illness. It has primarily been used in rheumatic conditions, but has been successfully used with other chronic diseases. The HAQ was selected in this study because it measures overall functional limitations as well as limitations in upper and lower extremities. It consists of 20 questions grouped into eight components reflecting activities of daily living such as dressing, walking, reach, and grasp. Participants evaluated their ability to perform these tasks during the first week after their fall.

The mean functional limitation, as measured by the HAQ score, was 1.5 (SD = 0.7) on a scale of 0 to 3, with higher numbers representing more limited functioning. The median HAQ was 1.38. The mean scores in samples with various rheumatic diseases, participating in multi-center studies, have been reported from a low mean score of 0.55 (SD = 0.1) for systemic lupus erythematosus to a high mean score of 1.34 (SD = 0.02) for rheumatoid arthritis.

With regard to individual tasks, participants reported having the most difficulty performing heavy chores (mean = 1.89; SD = 1.02), dressing themselves (mean = 1.54; SD = 1.05), and bending and picking up clothing from the floor (mean = 1.40; SD = 1.02). Tasks which caused the least difficulty were opening car doors (mean = .62; SD = .96), turning faucets on and off (mean = .34; SD = .72), and lifting a full cup or glass (mean = .31; SD = .71). There were no statistically significant differences in means among the trades with regard to HAQ scores, but the highest scores were reported by drywallers and plasterers, and the lowest were seen in electricians.

The HAQ scores provided useful information about the degree to which workers were disabled from falls during their first week of recovery. They were moderately correlated with days lost from

work ($r = .52$; $p < .001$), hence could prove useful to occupational health practitioners. Use of the HAQ was successful with this population; however, it needs to be evaluated in other samples to more conclusively determine its utility in evaluating occupational injury disability. Sequential administration would be useful to assess whether the HAQ is sensitive in detecting minor patient status changes over time.

Session 9: Methodologies Used to Collect and Analyze Surveillance Data

Formal Safety Analysis Methods as Tools for Hazard Surveillance—Kerkering JC

Traditional health surveillance methods are based on a disease-and-illness model. That is, the model is used to respond to the incidence of illness and disease by categorizing and counting such incidences and describing the circumstances surrounding the occurrence. This approach is dictated by perceptions of a cause-and-effect relationship where the cause is not readily observable and a significant time lapse lies between the initial cause (source) and its effect (illness). Hence, traditional health surveillance has, by necessity, often been reactive and descriptive rather than proactive and predictive.

Such a reactive surveillance model, as stated in the NORA research guideline document (p. 53), is deficient where the topic of concern is worker safety, and the effect of a triggered hazard is usually immediate with often fatal results. Surveillance activities, where used to prevent traumatic injury, must identify these workplace hazards and the conditions that trigger accidents. It is often possible to identify the causes of accidents in terms of hazards and triggering conditions and thus predict possible effects before an accident occurs.

The author claims that an effective hazard surveillance model for hazard identification and accident prediction requires a proactive approach, an approach that is feasible using well-established, systematic, safety-analysis procedures. This paper describes two broad safety-analysis approaches, inductive and deductive, and then suggests how these approaches can be used to anticipate accidents so that preventive measures can be taken. Preliminary hazard analysis is described as an example of an inductive approach, while fault tree and event tree analyses are described as examples of deductive approaches. The mining industry provides examples for each approach: a fault tree analysis of a blocked ore chute in a deep metal mine and a preliminary hazard analysis of a longwall escapeway in a coal mine. The author concludes that these methods could improve hazard surveillance results and provide new insights into cause-and-effect relationships related to risk and traumatic injury in mining.

Surveillance of Disaster - A View from the Denominator—Chaiken RF

Surveillance plays a very significant role in the NIOSH epidemiological model as applied to occupational health and safety. Surveillance studies are used in identifying occupational problems, evaluating the effectiveness of intervention procedures, establishing research priorities, and allocating resources for its health and safety program.

The NIOSH surveillance system has been highly successful in serving NIOSH's mission of prevention of occupational injuries as applied to relatively large number, relatively high frequency events such as falls, machinery mishaps, and environmental exposures. However in the case of relatively low number and low frequency industrial disasters such as explosions and fires, and commercial aircraft accidents, the applicability of the surveillance model is far less clear. I believe that some of the problem lies with worker exposure - its interpretation and evaluation, and some of the problem lies with assumptions (both explicit and implicit) as to weighting factors (i.e., economic, societal and hazard impacts) to be or not to be considered in the data analysis. I believe there is a definite need to broaden the data base that exists in current surveillance S&H models; particularly in the area of worker exposure.

These points will be elaborated on in terms of the 'numerator' and the 'denominator' of surveillance information, in which BLS and NIOSH surveillance studies revolve around a count of the injured (the numerator) normalized to some count of the workers exposed (the denominator). If one interprets the 'numerator' of surveillance rate data as referring to those individuals, institutions and events which are directly affected by accidents that occurred, then weighting factors that relate to the numerator (referred to as N-factors) can be defined based on degrees of hazard or injury and the economic and societal impacts that are directly associated with the occurrence of the accident.

The 'denominator' of surveillance data will likewise be affected by weighting factors, but the D-factors will refer to those individuals, institutions and events which are in harms way, i.e., those who will be affected by future accidents. As will be described, the D-factors being different from the N-factors, will lead to a ranking scheme which is different from that currently employed by NIOSH, but one that could lead to an all-inclusive model for epidemiologic analysis of accidents.

Another aspect of the model employed by NIOSH for prevention of occupational injury is what might be called the 'Haddon Strategy' for reducing injuries. With this paradigm, remediation efforts focus on those means available for reducing injuries associated with an accident, rather than on determining the exact cause(s) or 'anatomy' of an accident. For example, water purification will control disease even in the absence of specific knowledge as to the pathogens that would cause disease. Unfortunately, low frequency disasters, such as mine explosions and fires, often involve the liberation of energies so great that prevention of occupational injury dictates that the event must be prevented from occurring. This requires a fundamental understanding of the exact causes that can lead to the event. In these cases, it is only through a detailed anatomy (research) of an accident that solutions for prevention will be found.

The Effect of Using Death Certificate Information on Industry and Occupation Specific Fatality Rates—Wolf SH, Loomis DP, Gregory E, Runyan CW, Butts JD

Death certificates are a primary source of information used to estimate industry and occupation specific fatality rates for the United States. Funeral directors completing this information are instructed to record the decedent's usual industry and occupation. However, the usual industry and occupation during a decedent's lifetime, rather than their industry and occupation at the time of the injury, may be misleading in determining industry and occupation specific rates of fatal injury at work. The purpose of this study is to compare the

industry and occupation at the time of the fatal injury described by the medical examiner with the usual industry and occupation recorded on the death certificate and identify effects on computed rates.

Cases for the study were selected from records of the Office of the Chief Medical Examiner for North Carolina. All accidental deaths and homicides identified as “at-work” in the medical examiners’ system between 1977 and 1991 were selected for study. Information on usual industry and occupation was abstracted from death certificates in the medical examiner’s records and industry and occupation at the time of the fatal injury were determined from medical examiner investigative reports. Industry and occupation were coded to the U.S. Bureau of the Census. Tabular analyses describe the differences between usual and injury industry and occupation groups by fatality type (intentional and unintentional), age, gender and race. Case and population data were used to estimate industry and occupation specific rates of injury mortality per 100,000 worker-years.

The medical examiner’s system identified 2524 injury deaths on-the-job between 1977 and 1991; 2099 from unintentional trauma, 358 from homicide and 67 from poisoning or environmental conditions. Industry at the time of injury was known for 2465 cases and the overall agreement with usual industry was 78%. Homicides had a lower percentage of agreement (73%) than did cases of unintentional traumatic injuries (79%). Occupation at the time of injury was known for 2449 cases and the overall agreement with usual occupation was 75.3%. Percentage agreement for homicides (74%) was the same as for unintentional traumatic injuries (75%). The agreement between injury and usual industry or occupation did not differ by race or gender. For workers 65 years and older, death certificate data about industry was less likely to agree with data from the medical examiner (65.9%) than for workers aged 18-64 (80.7%). Crude mortality rates for unintentional traumatic injuries were underestimated for the ten leading industries and eight of the ten leading occupations using usual industry and occupation rather than industry and occupation at the time of the injury. For homicides, underestimates were observed for the two leading industries and occupation. Industries most likely to be affected by misclassification were: agriculture; forestry and logging; construction; truck and bus transportation; and grocery stores. Forestry and logging occupations and fishing, hunting and trapping occupations were most likely to be misclassified. While usual industry and occupation identifies the major industry and occupation groups at risk for fatal occupational injuries, its use can misstate actual fatality rates for specific industries and occupations.

Fatal Occupational Injury in North Carolina: Using Capture-Recapture Methods to Ascertain and Evaluate Annual Mortality from Multiple Data Sources—Hooten EG, Butts JD, Baker SP

Fatal injury in the context of one’s employment is a problem that seems relatively easy to define and, consequently, to enumerate. Unfortunately, investigation reveals an issue plagued by imprecise definitions that vary by data source and agency mandate, further complicated by confusion about the nature of activity at the time of injury and characteristics of the decedent’s employer as influences upon whether an injury death is characterized as on-the-job (OTJ) or not.

Capture-recapture methods were developed in animal ecology to improve the accuracy of estimates of wild animal populations; and,

these methods compare the number of animals caught from a given population in one capture effort with another survey done at a later time. By matching animals caught in both surveys and noting the differences, an estimate of the total population can be developed. Application of capture-recapture methods to fatal occupational injury, using multiple data sources as analogous to serial capture efforts, holds promise for improving the precision of annual fatal injury incidence estimates and the characterization of deaths as “truly work-related”. It further facilitates evaluation of differences between these datasets in terms of the types of cases found in each.

North Carolina has a centralized medical examiner system in which consistent effort is made to identify and record information for deaths on-the-job. In addition, North Carolina has its own Occupational Safety and Health Act (OSHA) program which collects information on fatal events within the purview of OSHA guidelines as well as a Worker’s Compensation Insurance Program and a death certificate file wherein the OTJ variable is collected on every death certificate. North Carolina also participates in the US Department of Labor’s Census of Fatal Occupational Injury Program (CFOI) in which each case is verified as work-related from at least two different sources, including all of those noted above.

For 1994 and 1995, the ME, death certificate, worker’s compensation, and OSHA data sets for North Carolina are examined to assess the concordance and discordance between them and, from that, to provide a more complete estimate of the “true” annual incidence (including confidence intervals) of fatal occupational injury using multiple source methodology (capture-recapture methods). The resultant aggregate estimate as well as its component parts (datasets) are compared to the CFOI dataset (the gold standard since inclusion in this set as a fatal occupational injury is confirmed by more than one source). Sensitivity and specificity analyses for each dataset are performed to identify areas of variation by age, race, gender, and other variables such as the decedent’s occupation/industry. Univariate and multivariate logistic regression are used to estimate the log odds (odds ratio) that a given type of case will be found in the component datasets and aggregate data when compared to CFOI. Policy and practice modifications that will have direct effects on the completeness of the data sources individually and in aggregate are discussed along with implications for the application of these methods to the development, implementation, and evaluation of prevention efforts.

Session 10: Measuring the Risk for Occupational Injury

A Decision Model for Use in the Allocation of Safety and Health Resources—Warrack B, Redekop T

There has been an increasing emphasis in jurisdictions on directing safety and health prevention activities to where they are most needed. To effectively accomplish this, better data and improved data analysis methods are needed. Data on occupational injuries and illnesses is useful to assist in deciding where to direct safety and health inspection activities. The model being proposed uses a number of decision variables to assist in deciding how to prioritize and focus efforts. Key to any model such as this is being able to use data to define, characterize the risks and quantify the risks to workers so that risks can be appropriately ranked and risk comparisons made so as to focus efforts. Manitoba jurisdiction data will be used to demonstrate how this model can be used in practice.

Also discussed will be some shortcomings and problems associated with using this type of data in decision models.

Re-conceptualization of Measuring Musculoskeletal Disorders: A Pilot Test of Telecommunications Workers—Griffin J

While reports of repetitive trauma injuries and disorders among workers have continued to increase over the past decade, little research has been done to either modify existing measures or to develop new measures that are valid and reliable. Having valid and reliable measures is essential to understanding the relationship between early signs of musculoskeletal strain and chronic musculoskeletal disorders; moreover, they may be important to understanding how strain increases the vulnerability to other work-related injuries.

For this project, the current literature on work-related musculoskeletal disorders was reviewed. Experts were consulted to determine the strengths and weaknesses of the frequently-used measures of musculoskeletal disorder symptoms. Combining the information from experts, findings from previous research, and other hypothesized relationships, a new measure of musculoskeletal symptoms was then developed and tested for validity and reliability. Eight anatomical areas (wrists, hands, fingers and forearms; neck; shoulders and upper arms; elbows; upper back; lower back; hips and thighs; feet and ankles) are included in the new measure. For each anatomical area, general questions about symptoms, such as pain, weakness, and limited motion are asked. Those reporting any symptoms are then asked more specific questions about limited activity, previous injury, medical treatment, and severity.

To test this new measure, surveys were sent to 179 telecommunication workers from a local labor union. All the workers surveyed have jobs that require them to use repetitive motions on computer display terminals for a majority of the workday. This work group is primarily women (80%), who are married (60%), with an average age of 37 years. The average length of time working for the current employer is 8.5 years.

Workers report general symptoms of musculoskeletal disorders most commonly in the neck; lower back; and hands, fingers, wrists or forearms. For each of these groups, about 70% of the sample report at least one general symptom (e.g., pain, limited movement) specific to that group. Approximately 45% reported at least one general symptom in their shoulders and upper arms.

Responses to questions about general symptoms of musculoskeletal disorders were also compared to a self-report of being medically-diagnosed with a musculoskeletal disorder. Workers were asked to report if they had ever been diagnosed with certain disorders, such as carpal tunnel syndrome or a back disorder to the muscles, nerves or discs. Of those who report having been diagnosed with carpal tunnel syndrome by a doctor, 88% answered "yes" to having all of the general symptom questions associated with hands, fingers, wrists or forearms. Of those who report ever having been diagnosed with a back disorder to the muscles, nerves or discs, 79% answered "yes" to having all of the general symptoms associated with the lower back.

This presentation will include a short analysis of the current measures, a discussion of the development of the new measure, a critique of the validity and reliability properties of the measurement,

and possible applications of this measurement to evaluate risk for acute and chronic injuries at the workplace.

New Biostatistical Approaches to Measure and Monitor Health Trends—Brant LJ, Bos AJG

Recent interest in monitoring health trends in individuals through repeated health examinations has led to a realization that one of the challenges facing these programs is to distinguish aging and disease from other health-related events. Aging and disease progression are both processes of change in individuals occurring over the course of time, and can be affected by the occurrence of numerous events in the individual's living and working environment. Both age changes and disease have a direct impact on the function of the individual and thus needs to be accounted for in any monitoring process of the individual. The process of change occurs in everyone, but it is a highly individual phenomenon that occurs differently from person to person. Some individuals may change very little with regard to a particular health-related outcome, while others may show increasing or decreasing trends of the outcome. In order to monitor and better understand health trends in individuals, biostatistical approaches must be available that allow investigators and clinicians to examine the different patterns of change over time among persons as well as account for the natural heterogeneity among individuals. Such an approach must be able to predict each person's response even if that response differs substantially from the average response for the population. Information for describing patterns of individual response requires the development of a medical history that is obtained by monitoring a particular outcome for each individual over time. This paper discusses a new biostatistical approach that is appropriate for monitoring individual health trends and describing the natural heterogeneity in the study population. Results from the approach can be used in identifying individuals with deviate or abnormal patterns of response. Examples of applying the approach include the monitoring of prostate specific antigen as a diagnostic tool for prostate cancer and the monitoring of blood pressure as a diagnostic tool of heart disease. These biostatistical tools have significant potential for research and practice in health evaluation, health prediction, and the development and promotion of injury and disease prevention strategies.

Counting Concepts: Estimating the Population-at-risk for Regulatory Action—Botkin A

Before an OSHA regulation can be enacted, a considerable amount of study and analysis is devoted to the supporting materials needed for the rule, and its regulatory impact analysis, or RIA. The need for regulatory impact assessments is created by Executive Orders, as well as Congressional and judicial actions which require Federal agencies to evaluate the impact of proposed regulations.

A significant issue in the development of a regulatory impact analysis is estimation of the population-at-risk. This value characterizes the baseline, drives the estimate of potential benefits as well as the cost of compliance in achieving reductions in the hazard following implementation of regulations. But for most regulatory actions there is no statistical data service that can provide a count of the specific entities or occupations affected by the proposed rule.

Like many other important aspects of safety and health regulation, a confined space is a concept. It is instantly recognizable to informed safety professionals, but it is of little importance in any

other business or economic context and thus not enumerated or examined in statistical data. This presentation will illustrate the research and development of this important metric for the OSHA general industry confined spaces standard, and the development of its analogue in the construction industry standard on confined spaces.

Session 11: Fall-related Injuries in Construction

Slipping, Tripping, and Falling Incidents: Steel Erection and Metal Roofing Workers—Murphy PL, Cotnam J, Sorock G

Falls in construction are a serious problem. In a recent study (Leamon and Murphy 1995), 38% of workers' compensation claim costs in the construction industry were associated with falls. The incidence of falls was 4.9 falls per 100 full time workers. A per capita cost was calculated at \$560 per employee for direct medical and indemnity costs. Steel erection workers and roofers have been identified as high risks for falls in the construction sector, but limited international research on the risk factors or causes have been identified in the literature (Suruda et al., 1995, Flett 1992, Hardesty et al., 1993).

This study is a retrospective analysis of workers compensation claims over a seven year period, with over 90,000 claims specific to worker's compensation job classifications for steel erection workers, bridge workers, and metal roofing. The number of slipping, tripping and falling incidents and the relative cost of falls are examined by injury type, body part and occupation. Aggregate frequency and severity of events, and relative individual claims costs are presented. Details on type of fall, the location of the slip, trip or fall, the walking surface and condition or contaminant, employee activities, and although very limited, footwear worn, when the incident occurred will be extracted from individual narrative accident descriptions. The available narrative description is limited to 120 characters. Algorithms based on word frequency and usage were developed for this analysis.

Specific goals of the study are to identify the scope of occupational injuries, and antecedent events for workers exposed to metal roofing, decking, and beams, determine the significance of slipping incidents for falls on the same level and falls from elevation and compare with tripping, loss of balance, falls through openings, from perimeters, from scaffolds and other locations. Additionally, this study determines the significance of slipping incidents that occur on steel beams, decking and roofing and compares them with slipping incidents on other surfaces like ladders, concrete and plywood.

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Nonfatal Falls in Construction Workers: Predictors of Injury Severity—Gillen M, Faucett J, Beaumont JJ, McLoughlin E

The study evaluated injury severity in a group of construction workers who sustained nonfatal falls at work. The convenience sample consisted of 255 adults, predominantly males (97%) with a mean age of 34.6 years (SD = 9.3), who were identified from Doctor's First Reports submitted to the California Department of Industrial Relations. A full range of construction trades was represented in the sample population. More than one quarter of the sample were union members, and more than half worked in residential construction. For those that fell from heights (76%), the mean height of the fall was 9.2 feet (SD = 7.1).

Two measures of injury severity were used - the Injury Severity Score (ISS) and the disability section of the Stanford Health Assessment Questionnaire (HAQ). There were 518 injuries including 61 extremity fractures. Thirty-two individuals were hospitalized and 41 required surgery. Seventeen participants (7%; 95% CI, 4 to 10%) were deemed permanently disabled. A simultaneous multiple regression model, using five independent variables, explained 21% of the variance in HAQ scores. Nonunion status and poorer safety climate scores indicating increased risk were positively correlated with higher HAQ scores, as were greater heights and impact on concrete surface. The mean number of lost days was 44.3 days (SD = 58.6), and the median was 10 days. Both measures of injury severity were moderately associated with a greater number of days lost from work (ISS: $r = .43$; $p < .001$; HAQ: $r = .52$; $p < .001$).

Almost half of the sample (46%) were involved in direct installation when they fell, and 91% were performing their usual duties. The most frequently reported specific activity being performed at the time of the fall was walking (22%), followed by descending (11%), and climbing (10%). Workers who fell from a height, fell most often from ladders, scaffolds, or planks (41%), followed by roofs and wood skeletons (24%). Forty six percent of the sample fell from heights of six feet or more.

The Safety Climate Measure score was significantly associated with union status ($r = .225$; $p < .001$), and is most likely explained by five items in the instrument where union and nonunion members differed in their perceptions regarding safety conditions at their job site. Union members were more likely than nonunion members to perceive supervisors as caring about their safety, be made aware of dangerous work practices and conditions, have received safety instructions when hired, have regular job safety meetings, and not perceive that taking risks was a part of their job.

These findings confirm that falls in construction are far too common, suggest that injury severity and disability associated with falls is notable, and identify key target areas for intervention and prevention such as management commitment to safety, ongoing worker training, and hazard identification and control.

Risk Factors of Task Performance at Elevated and Inclined Surfaces—Bagchee A, Bhattacharya A, Succop P, Medvedovic M, Mitchell T

A majority of fatal and non-fatal accidents at the workplace occur due to fall-related incidents, particularly in the construction industry with twice the rate of nonfatal falls as the average industry. Most falls result from momentary loss of postural stability of the worker. Working on elevated and/or inclined surface can produce excessive demand on the postural control system of the worker. For example, ironworkers and roofers traditionally work at raised and/or inclined surfaces and account for 70% of fall-related fatalities. A laboratory-based study was performed to investigate the effect of surface elevation, surface inclination, environmental lighting and noise on postural stability of workers performing simulated tasks. Twenty young (age = 3D 25.0 = F1 2.2 years) and twenty old (age = 3D 53.7 = F1 3.2 years) industrial workers, with equal number of males and females in each group, participated in the study. The subjects performed three kinds of tasks of Stationary, Bending, and Reach. The subjects performed these tasks on specially constructed surfaces with combinations of three levels of elevation (0, 30.5, and 61 cm high), and three levels of inclination (0, 14, and 26 degrees). The environmental lighting was varied between poor (< 0.2 footcandles) and good (> 40 footcandles). The subjects were fitted with lightweight wireless headphones that presented audible distraction in the form of pre-recorded construction sound at a setting sufficiently loud to interfere with levels of normal human conversation. The forces and moments exerted by the subjects were recorded using a piezo-resistive force platform and the data was analyzed to yield the movement of the center of pressure (CP) as a quantitative measure of postural sway. Stepwise regression analysis was used for identifying the significant interactions. Dependent variables included the measures of sway area and sway length, with the age, height/weight ratio, and gender included as covariates. Mixed model analysis showed highly significant fixed factor effects for elevation ($p < 0.001$) and environmental lighting ($p < 0.001$) for all three tasks for both sway area and length, with increasing sway area and length for increasing elevation and inclination. The sway length increased significantly with increasing inclination for the Bending and Stationary tasks, but was non-significant for the Reach task. Sway area increased significantly ($p < 0.05$) with increasing inclination for all three tasks. The results are indicative of postural balance performance that deteriorates with increase in elevation of the working surface as well as the inclination of the surface. This introduces additional burden and may be a major contributor to momentary loss of balance resulting in falls. Environmental lighting was also found to be a significant risk factor and introduced further burden on the postural stability of the worker. The experiment was performed under laboratory conditions, with no workload and on firm support surface with sufficient coefficient of friction. These risk factors may further jeopardize the postural stability of the worker at an elevated and/or inclined surface. Results from this study would be helpful in identification of specific risk factors and their relative contribution in postural imbalance during dynamic task performance on inclined and/or elevated surfaces.

Fall Prevention in Construction by Organizational Intervention—Becker P

This paper will present the results of a research project to evaluate an innovative organizational intervention to prevent falls in con-

struction. This intervention research is funded by the Center to Protect Workers' Rights and NIOSH.

Falls are the leading cause of injury in construction. The construction safety literature recognizes available engineering controls, work practices, and personal protection which are effective in preventing construction falls. However the equipment and practices are not widely used in the industry.

This project implements a construction contractor certification program called Fall-Safe to improve management use of existing fall prevention methods and to develop an accountability system on job sites to maintain appropriate controls in the dynamic construction setting. WVU Safety and Health Extension serves as the certifying organization for contractors in West Virginia, and is assisting contractors in developing office and site fall prevention programs, training of supervision and workers, and quarterly audit of both company and site fall prevention efforts.

Fall-Safe has been successfully marketed to contractors as a way to increase the contractor's marketability to large purchasers of construction services. Initial development of the program enlisted the Appalachian Construction Users Council, an organization of industrial plants who regularly use construction services. With the support of the construction users, contractors eager to work on these sites have enlisted as Fall-Safe Participants.

The Fall-Safe program incorporates a rigorous evaluation component using comparisons of intervention and control groups of workers and contractors. Baseline measurements and twice yearly measurements are compared prospectively between contractors in northern and southern WV working for American Electric Power.

Measures include contractor, worker, supervisor attitude and knowledge surveys, and an observational scoring system carried out on sites determining use of appropriate fall prevention techniques. In the longer run, the project will include sufficient power to compare Workers' Compensation claims for falls between intervention and control groups.

Session 12: Injury Mechanism and Rehabilitation

Severe Repetitive Strain Injury-Focal Hand Dystonia: Central Neural Consequences Versus Local Tissue Injury—Byl NN

Repetitive strain injuries are reaching epidemic levels in the workplace despite increased ergonomic attention to the work site. It has been hypothesized that repetitive strain injuries result in tissue microtrauma following the biomechanical stress of repetition. Recently central neural consequences have been reported. The question is whether severe RSI-Focal hand dystonia results from severe sensory degradation of the hand representation on the somatosensory cortex or local tissue microtrauma including adhesions or inflammation. Owl monkeys were trained in a behavioral paradigm of rapid active opening/closing of the hand under conditions of high cognitive drive. This led to the development of motor problems which appeared to simulate focal hand dystonia. Severe degradation of the hand on the somatosensory cortex was measured. Post mapping, the monkeys were taken to the anatomy lab for careful dissection of the flexor tendons and histological study of the ten-

dons and the median nerves. The anatomical dissections of the flexor tendons and the nerve were normal for all monkeys except the monkey that developed the focal hand dystonia, most specifically involving the fourth digit, in an unusually short period of time (5 weeks). The cortical penetrations in area 3b showed large receptive fields and a high proportion of multiple receptive fields involving D4 and adjacent digits, as well as multiple receptive fields which overlapped the glabrous and dorsal surfaces. On the anatomical dissection, the profundus tendon of D4 was adherent across the middle phalanx. Interestingly, the same adhesion was seen on D3 on the untrained side. There were no signs of inflammation of tendons or the median nerve on any of the digits on either hand. These studies suggests that severe RSI-focal hand dystonia may result from a degradation of the somatosensory representation of the hand without local pathology. This suggests that treatment needs to address the neural consequences of the disorder and not just the biomechanical effects.

Reliability, Validity, and Clinical Utility of a Battery of Physical Performance Tests for Patients with Low Back Pain—Olson SL

Low back pain is a wide spread and costly work-related problem that leads to physical dysfunction. Clinical evaluations are based upon measures of impairment such as range of motion, strength, and pain. Physical performance measures have potential utility for evaluation, treatment planning, and determination of treatment outcome, yet few measures have proven reliability and validity. The purpose of this study is to determine the reliability, validity, and clinical utility of eight physical performance measures. Subjects: A control group of 48 healthy subjects and a group of 44 subjects with current low back pain (LBP) participated in this study. Procedure: The following physical performance tests were used: 1) Ten repeated trunk flexions; 2) Five repeated sit-to-stands; 3) Timed up and go; 4) Loaded forward reach (with load of 10% body weight); 5) Unloaded forward reach; 6) Five-minute walk (distance measured); 7) Fifty-foot walk (preferred and fast speeds); and 8) Sorensen fatigue test. The reach tests were measured in cm. and the timed tests were measured in seconds. Lumbar flexion was also measured. The subjects repeated this battery of tests twice a session at two separate sessions. The order of tests was randomized except for the Sorensen test, which was performed last. Two testers were randomly selected from a group of six to assess each subject. Data Analysis: ICC Model One analyses were used to determine intertester, test-retest, and day-to-day reliability values. A two-way multivariate analysis of variance (group by gender) and follow-up univariate analyses were conducted on all variables to test validity. Pearson correlation coefficients were calculated among the physical performance measures to determine convergent and discriminant validity. Results: Intertester reliability was above .95 for all variables across both groups. Test-retest reliability was above .83 for all measures across both groups except repeated flexion, which was .7 for the control group and .45 for the LBP group. Day-to-day reliability ranged from .46 to .76 for the control group and .59 to .88 for the LBP group. Day-to-day reliability values were higher when comparing the averages of 2 trials in the control and LBP groups, .62 - .89 and .76 - .91, respectively. The results of the MANOVA showed a significant effect of group only ($F=3.25$; $df=11,62$; $p=.002$). Univariate analysis revealed significant group differences on all variables except unloaded forward reach and 50-foot walk at preferred speed. In the LBP group, strong correlations

were found among the 5-minute walk, 50-foot walks, and timed up and go ($r=.78-.96$). Lumbar flexion angle correlated poorly with repeated flexions ($r=-.16$). For the control group, the highest correlation was between the timed up and go and the 50-foot walk ($r=.67$). Conclusions: Overall these measures had adequate reliability and validity. Averaging 2 trials for the repeated flexion and sit-to-stand tests is recommended to increase reliability. The measures show good clinical utility as they are easy to perform, acceptable to all subjects, and require little equipment.

Ergonomics and Work Injury Management: 15 Years of Application in a Clinical Setting—Khalil TM, Steele-Rosomoff R, Abdel-Moty E, Rosomoff HL

The goal of rehabilitation of work injuries encompasses preventing disability through functional restoration and immediate return to a productive lifestyle. Due to the complex nature of the problem, it has been well recognized that chronic pain management requires a multidisciplinary approach since no one physician or therapist has the expertise or resources to manage this condition. One discipline that can contribute, significantly, to pain management is Ergonomics. Ergonomics studies deal with safety, human performance analysis, work environment, and other studies of value to the rehabilitation process. Also, due to its nature as an interdisciplinary science, it can offer solutions to many problems related to injury and its prevention. The Ergonomics Division of the University of Miami Comprehensive Pain and Rehabilitation Center (Miami Beach, Florida, USA) is an example where ergonomists work daily with members of the multidisciplinary rehabilitation team to solve problems in pain management and return to work issues. Over the past 15 years, the Ergonomics Division has integrated its activities and resources into the organization chart of the Center to address many complex problem from both the engineering and the medical perspectives. For the first time, this has provided the scientific basis for the rationalization of many treatment approaches. Through applied research activities, dissemination of valuable information and data was possible and new untraditional treatment approaches and techniques were developed. In the area of patients care, ergonomics contributes to the determination of the functional status of the low back pain patient through the establishment of profiles of functional abilities. This is done through a battery of quantitative measurements that help establish a human performance profile for each patient upon admission and throughout rehabilitation. The goal of treatment is, then, to condition the injured individual and to restore functional levels to the "normal" capacities of healthy uninjured individuals. The performance profiles are then compared to the physical demands dictated by the job. The objective here is to determine intervention strategies for matching the physical capabilities of the individual to specific job task. Ergonomics job analysis, job simulation, and job-site visits are used to prepare the injured worker to reenter the productive job market and lead a normal life style. Ergonomics knowledge pertaining to workplace design and expert systems is used to help patients adjust their workplace in order to minimize potential stresses due to poorly designed and/or improperly adjusted workplaces. Ergonomists also assist in the selection of jobs that match the measured functional capabilities of the rehabilitated persons. This paper will outline the history, rationale, methods, and various interventions which have been developed and tested in our facility.

Forearm Muscle Oxygenation Decreases During Low Levels of Brief, Isometric Contraction—Murthy G, Hargens AR, Kahan NJ, Bach JM, Rempel DM

Introduction. Regional muscle pain syndromes can be caused by repeated and sustained exertion of a specific muscle. Such exertion may elevate local tissue fluid pressure, reduce blood flow and tissue oxygenation (TO_2), and cause fatigue, pain and functional deficits of the involved muscle. Low levels (less than 20% maximum voluntary contraction (MVC)) of prolonged static contraction of the upper extremity are common in many occupational settings and may cause fatigue (1). The purpose of our investigation was to determine whether TO_2 decreases significantly at low levels of static contraction of the extensor carpi radialis brevis (ECRB).

Methods. Healthy male and female subjects ($n=9$) participated in the study after providing written informed consent. The protocol was approved by the University Human Research Institutional Review Board. Each subject was seated, right arm was abducted to 45° , elbow was flexed to 85° , right forearm was pronated 45° , and wrist and forearm were supported on an arm rest throughout the protocol. Altered TO_2 was measured noninvasively using near infrared (NIR) spectroscopy (2). This technique has been validated previously (3). The NIR probe was placed over the ECRB muscle and gently secured with an ace wrap. MVC was determined initially and the subject rested for an hour prior to subsequent tests. After one minute of relaxed, baseline measurements, four different loads (randomly ordered) were placed just proximal to the metacarpalphalangeal joint such that subjects isometrically contracted the ECRB at 5, 10, 15, and 50% of MVC for 1 minute each. A 3 minute recovery period followed each contraction level. At the end of the protocol, with the NIR probe still in place, an ischemic TO_2 was obtained to establish a zero level for each subject. NIR data were normalized to a relative scale between the physiologic minimum (0%) established during ischemia and the spectrophotometer output at baseline (100%).

Results. After 35 and 40 seconds of contraction, TO_2 plateaued at below baseline levels and remained at that level throughout the contraction period. Mean TO_2 decreased from resting baseline (100% TO_2) to $89 \pm 4\%$ (SE), $81 \pm 8\%$, $78 \pm 8\%$, and $47 \pm 8\%$ at 5, 10, 15, and 50% MVC, respectively. TO_2 levels at 10, 15, and 50% MVC were significantly lower ($p < 0.05$; RANOVA and Tukey's follow-up) than baseline values. TO_2 recovered to baseline values within 3 minutes following contraction.

Discussion. This study demonstrates a significant reduction in TO_2 even at sustained contraction levels as low as 10% MVC. Tissue deoxygenation during prolonged isometric muscle contraction may play an important role in the development of work-related muscle fatigue and pain. Static or dynamic contraction with inadequate recovery time may sustain elevated intramuscular pressures, and reduce blood flow and TO_2 , and cause muscle fatigue and pain. Although the duration of static contraction in our study was only 1 minute, the observation that recovery to baseline TO_2 took between 30 seconds to 3 minutes indicates that a low contraction level even for a brief period is sufficient to reduce TO_2 significantly. Therefore, sustained tissue hypoxemia associated with low levels of sustained contraction may provide a mechanism to explain work-related muscle dysfunction.

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Session 13: Intervention Evaluation

Preventing Drownings in Alaska's Commercial Fishing Industry—Conway GA, Lincoln JM

Introduction. The Arctic and subarctic waters of Alaska provide a very hazardous work setting, with great distances, seasonal darkness, cold waters, high winds, brief fishing seasons, and icing. Deaths have been inordinately common in Alaska's commercial fishing industry. Over 90% of these deaths have been due to drowning or drowning plus hypothermia, following vessel capsizings and sinkings. During 1991 through 1994, the U.S. Commercial Fishing Vessel Safety Act of 1988 (USCFVSA) required the implementation of comprehensive prevention measures for all fishing vessels in offshore cold waters, including immersion suits, survival craft (life rafts), EPIRBs and crew training in emergency response and first aid.

Purpose. To examine the effectiveness of the measures instituted under the USCFVSA in reducing the high occupational fatality rate (200/100,000/year in 1991-1992) among Alaska's commercial fishermen

Method. Comprehensive surveillance for commercial fishing occupational fatalities was established by our office during 1991 and 1992 in Alaska. Demographic, risk factor, and incident data for 1991 through 1996 were compiled and analyzed for trend.

Findings. During 1991-1996, there was a significant ($p=.002$) decrease in Alaskan commercial fishing-related deaths, from 36 in 1991 to 35 in 1992, 22 in 1993, 11 in 1994 (artificially reduced number due to closure of crab fisheries that year), 18 in 1995, and 24 in 1996. While man-overboard drownings and vessel-related events in crabbing (often conducted far offshore and in winter) have continued to occur, marked progress (significant downward trend, $p<0.0002$) has been made in saving lives of those involved in vessel-related events:

Year	Vessels Lost	Persons on Board	Persons Killed	Case Fatality Rate*
1991	39	93	25	27%
1992	44	113	26	23%
1993	24	83	14	17%
1994	36	131	4	3%
1995	26	106	11	10%
1996	38	114	13	11%

*Case Fatality Rate = (number killed/number at risk) x 100 percent

Conclusions. Specific measures tailored to prevent drowning in vessel capsizings and sinkings in Alaska's commercial fishing in-

dustry have been very successful so far. However, these events continue to occur, placing fishermen and rescue personnel at substantial risk. Additional efforts must be made to reduce the frequency of vessel events, enable similar progress in crabbing fisheries, and to prevent man-overboard events and drownings associated with them.

Methodological Criteria for Evaluating the Effectiveness of Accident Prevention Programs—Shannon HS, Robson LS, Guastello SJ

Despite the large volume of occupational safety literature, which is often descriptive or examines physical risk factors, accident prevention programs are often not evaluated. Moreover, the quality of evaluations that do take place has been criticized. Commonly occurring methodological weaknesses include: not taking into account length of exposure when calculating accident rates; the use of proxy measures for outcome measures, without validating the use of the proxy; not monitoring large workplace/societal changes which could influence accident rates, especially in the case of before-after designs. There are, no doubt, many reasons for this situation - among them is a lack of training in evaluation in those responsible for occupational safety within organizations. Yet rigorous assessments of our efforts in promoting safety are essential if we are to avoid using limited human and financial resources on ineffective (or even harmful) measures.

In the following, we describe a set of methodological criteria, derived in order to assess the quality of reported evaluations of safety interventions. These criteria can also serve as a reference for those planning such evaluations. Identification of the criteria was based on an examination of the safety, health promotion, program evaluation and research design literatures. Eight areas were deemed relevant:

1. Program objectives—e.g., Did the program objectives provide a measure against which outcomes could be compared?
2. Program design—e.g., Was experimental, quasi-experimental or non-experimental design used?
3. Program participants—e.g., Was selection bias considered?
4. Description of the safety intervention(s)—e.g., Was exposure to additional societal/workplace factors considered?
5. Measurement of program implementation—e.g., Was description/measures of compliance of program recipients provided?
6. Measurement of program outcome—e.g., Were true outcome measures provided?
7. Analysis of results—e.g., Was sample size/statistical power considered?
8. Conclusions—e.g., Were conclusions supported by the analysis?

Some of the criteria are applicable to field experimentation in general, but emphasis has been given to issues in the safety field.

Baseline Safety Measures in the First Year of the New England Safety Project—Halperin K

In the fall of 1996 the United Brotherhood of Carpenters Health and Safety Fund (UBCHSF), working with researchers from the Johns Hopkins School of Public Health, was awarded a three year grant from NIOSH in injury prevention among union carpenter contractors in New England. The aim of this project is to demonstrate that injuries to carpenters can be measurably reduced by the implementation of written health and safety programs by small construction contractors. The methodology is a controlled pro-

spective trial among small firms employing unionized carpenters. Twenty-two small-to-medium sized carpenter contractors (with average annual employment approximating 10 to 50 carpenters) in the Boston, MA, Hartford, CT and Providence, RI areas were recruited into the treatment group. The control group consists of 50 similar (in size and types of work) contractors in upstate New York. The geographical separation should minimize contamination. The treatment group will implement, with UBCHSF help, a written health and safety program. Using OSHA-required injury logs and workers' compensation data, this project seeks to demonstrate how the implementation of written health and safety programs by such contractors can lead to a measurable reduction in the rate of occupational injuries. Implementing this intervention over a two-year period is expected to result in a reduction in OSHA-recordable injuries, lost workday injuries, and days lost from work due to injuries, and in reduced workers' compensation experience modification rates. This project will also seek to demonstrate that the implementation of health and safety programs will result in measurable changes in workplace safety and health practices by participating contractors. Four "sentinel" safety and health practices are being measured through direct observation in actual workplaces: use of eye protection, use of ground fault circuit interrupters, use of hearing protection, and fall protection. Contractor and worker interviews are being used to gather information about the implementation of the intervention, and particularly about the perceptions of these two groups regarding the degree of acceptance of the intervention. The control group will be given an initial workplace visit with occupational safety and health advice (comparable to the baseline visit for the treatment group) and the promise of help in installing health and safety programs in their companies at the end of the two year period. Periodic measures of the sentinel practices will occur for both the control and treatment groups throughout the period, and the OSHA logs and experience modification rates collected before and after the period. Baseline information about workers' compensation experience modification rates, OSHA recordable injury rates, and occupational safety and health practices as represented by observation of the four "sentinel" practices will be presented for both the treatment and control groups. The next steps of the project will be outlined.

A Meta-Analysis of Long-Term Results for a Behavior-Based Method to Reduce Workplace Injuries—Krause TR, Sloat KCM, Seymour KJ

Research and applications of behavioral principles have established behavior-based safety initiatives as effective, proactive, and long-term solutions to occupational health and safety challenges. This study adds to the existing literature a longitudinal evaluation of an injury prevention process implemented in real-world industrial settings where the behavioral causes of injury varied from one site to the next. These highly individual initiatives shared 4 components: specification of critical behavior, observation/data collection, feedback, and problem-solving. Up to four years' injury data from sixty companies representing the chemical, petroleum, paper, lumber, electronics, transportation, food, and other industries who implemented this behavior-based safety process were examined. The average reduction from baseline amounted to 29% after 1 year of observation and feedback, 46% from baseline after 2 years, 50% after 3 years, and 59% after 4 years. Results did not depend on union status, industry, or baseline recordable rates and perceptions of success within the organizations concurred with these findings.

Preventing Accident Repetition—Developing Effective Multi-Partner Teams for Reducing Workplace Injuries—Gallie KA, Jessup BA

In Part one we provided background information on workers having experienced 20 or more workplace injuries reported to the British Columbia, Canada Workers' Compensation System ($n = 15,042$; $X = 25.4$ injuries/worker per working lifetime, range = 20 - 91 injuries; $SD = 10.9$). Our analyses showed that this group had an increased chance of permanent disability and risk of fatality. These workers reflected the "Tip of the Iceberg" and if effective proactive measures were not quickly taken there would soon be a larger number of workers facing similar workplace suffering. As example, our records showed that an alarming number of workers experienced at least 1 injury/year.

Given the need to intervene with workers most likely to benefit from our interventions we widened our selection criteria to include those workers with at least 5 injuries/5 years. This latter group represents 80% of our intervention group.

Communication with our occupational health and safety stakeholders including employer, worker, union/shop stewards, health and safety committees as well as in-house personnel (i.e., prevention officers, adjudicators) shaped development of the three injury reduction interventions we developed. These interventions were guided by two main goals: To show stakeholders the win-wins of adopting Health and Safety as their common goal and the role each could take (i.e., employer and disability/case management etc.) and focus their efforts on preventing accidents before they happened.

Three main interventions were developed. The first was a personalized letter from our President/CEO requesting all BC employers and workers with 20+ or 5 injuries/5 years to join in a partnership with WCB in bringing down the number of workplace injuries and provided guidelines on how this could be done. The second intervention consisted of a Preventing Accident Repetition Workshop offered to workers currently away from their job due to a workplace injury. This one day workshop included information on the causes of workplace accidents and how to prevent them, proper body mechanics and work simplification, stress and coping strategies, as well as a personal injury profile analysis and commitment towards safety. There was an overall psychosocial focus with coverage on the legal responsibilities towards Occupational Health and Safety. The third intervention comprised meetings with employers and their health and safety/union representatives where WCB representatives presented a Health and Safety analysis on that workplace including their injury profile (i.e., type and mode of injury, body region, occupation group, cost and lost person hours) as well as suggestions/guidance on establishing/maintaining an effective and comprehensive occupational safety program. Results of each intervention and conclusions will be discussed.

Session 14: Surveillance of Emergency Department and Hospitalized Injury

Work-related Injury in a Rural Emergency Department (ED) Population—Williams JM, Furbie P, Dirk S, Higgins D, Prescott J

Methods. An emergency department-based injury surveillance system (EDBISS) was used to collect injury data on all ED patients

seen over a one year period. A patient was classified as injured if their record contained an ED log injury code, an ICD-9 N-code between 800 and 995 in any diagnostic field, an E-code, or an entry in the trauma registry. An injury was considered work-related if the patient reported that the injury had occurred while at work. Descriptive analysis of the data was performed.

Results. Work-related injuries accounted for 1539/12,321 (12.5%) of all injuries. The mean age of patients injured on the job was 33.8 years (range, 16-77) compared to a mean age of 27.7 for all injured patients. Males accounted for 1026/1537 (67%) of the work-related injury visits compared to 57% of all injury visits. The most common mechanisms of work-related injuries were: overexertion (313 or 20%); cut or pierced by sharp implements (248 or 16%); falls (250 or 16%); struck by object (202 or 13%) and transportation-related injuries (71 or 5%). Sprains and strains were the most common type of injury sustained (415 or 27%), followed by wounds to upper limbs (283 or 18%), contusions (182 or 12%), and fractures (151 or 10%). Of the 1,539 patients presenting with occupational injuries, 178 (12%) presented to the ED via EMS. 1,401 (91%) were treated and released from the ED and 136 (9%) were hospitalized. The mechanisms of injury that most commonly resulted in hospitalization included struck by an object (28 or 21%), transportation (26 or 19%), falls (27 or 20%), crushing mechanism (13 or 10%), and machinery (20 or 15%). Of those requiring hospitalization, 132/136 (97%) were male and the average length of stay was 4.4 days. Four of the hospitalized persons died of their work-related injuries. Known medical charges incurred by patients injured at work were as high as \$62,622. The average charge for those treated and released was \$273 dollars; the average charge for those who required hospitalization was \$10,910.

Conclusions. Occupational injuries contribute significantly to the overall incidence of injuries seen in our emergency department and are responsible for tremendous medical charges each year.

Work-Related Visits to Emergency Departments in the United States, 1995—Stussman B

Introduction. It is well known that a significant portion of health care utilization occurs for occupational injuries. Care is sought in a variety of settings including physician offices, clinics, employer health units, and emergency departments (EDs). An injury resulting in a visit to the emergency department may be more severe than one ending up in another setting. This paper examines various aspects of emergency department visits resulting from work-related injuries. An estimated 96.5 million visits were made to hospital emergency departments in 1995. Of these, 4.8 million visits were work-related. This paper examines the extent of ED utilization for injuries that occur while working. Data are presented on the most frequent causes of injury, the types of injury, diagnostic services and procedures, and demographic characteristics of the patient.

Purpose. To describe work-related visits to emergency departments in the U.S.

Method. The data presented were collected from the 1995 National Hospital Ambulatory Medical Care Survey (NHAMCS). The NHAMCS is a national probability survey of visits to emergency and outpatient departments of non-Federal, short-stay and general hospitals in the U.S. Sample data were weighted to produce na-

tional estimates. In 1995, there were 391 emergency departments that provided data for the survey. Hospital staff were asked to complete Patient Record forms for a systematic random sample of patient visits occurring during a randomly assigned 4-week reporting period. The number of Patient Record forms completed for EDs was 21,911, of which 1,058 were work-related. Work-related visits were defined as visits for injuries that occurred while the patient was engaged in work-related activity on or off the employer's premises. Data were collected on up to three external causes of injury, up to three physician's diagnoses, procedures provided, and diagnostic and screening services ordered or provided.

Findings. Of the 37.2 million ED visits that were for injury, nearly 13 percent were related to work (4.8 million). One-fifth of injury-related ED visits for persons 18-64 years were related to work. Open wound of finger was the leading diagnosis for work-related ED visits. About seventy percent of visits were made by males (73.8 percent). The leading external cause of injury for work-related ED visits was overexertion and strenuous movements. Wound care was provided at 33.7 percent of work-related visits, and 8.0 percent had orthopedic care provided. Some form of imaging was performed or ordered for 64 percent of visits, with extremity X-ray being the most frequent (29.0 percent). Three-quarters of work-related ED visits had worker's compensation as an expected source of insurance. The work relationship was unknown for a quarter of injury-related ED visits.

Conclusions. The average total cost for an emergency department visit has been found to be \$209, totaling a billion dollars annually for work-related visits. Work-related visits comprise a small but significant portion of the health care provided in emergency departments. It has been estimated that 30% of injuries to the hands and feet could possibly be prevented by the wearing of appropriate personal protective gear in the workplace. Since open wound to finger and contusion of lower limb were the top two diagnoses for work-related emergency department visits in 1995, determining appropriate preventive action may result in financial savings for industry and health care systems.

Surveillance of Work Injuries Using Hospital Discharge Data— Trent RB

In a growing number of states, records of hospital stays, hospital discharge files, are coded for cause of injury with one or more E-codes from the International Classification of Diseases, Ninth Edition. Discharge records also include information on the patient, treatment, outcome, and charges. When the payer is coded as workers compensation the condition can be considered work-related as determined by the clinicians assessment of the patient's history. Using 1995 discharges from California's 587 acute care hospitals, we identified nonfatally injured patients age 16-64 where the expected payer was workers compensation (N=7,622, or 6%) and other payers (N=111,081, or 94%). We compared work versus nonwork patients and found that work injuries are distinct from nonwork injuries. Work injuries were 6 in 10 of all machine injuries, 5 in 10 of electrical injuries, and about 2 of 10 injuries due to explosions, struck bys, and fire/flames. We confirmed this pattern when we looked at fatal work injuries (using modified NTOF methods) and found that work injuries comprised the majority of injuries due to machines, explosions, electricity, and struck bys.

Within broad injury types, work injuries may be common for some specific etiologies and not others. For example, falls are the most common hospitalized injury, comprising 9% of work injuries and 6% of nonwork injuries. However, some specific types of falls are much more likely to be work related. Examples are falls from scaffolds (56% work related), ladders (23%), buildings (18%), and to a lower level (17%). In contrast, there are very few work related falls from wheelchairs (3%) or playground equipment (2%).

Hospital discharge data have several strengths for work injury surveillance: (1) one can document serious nonfatal work injuries in a number of states using a passive, uniform system, (2) for severe, nonfatal injuries, hospital discharge data are likely to be highly specific and sensitive, (3) differences between work and nonwork injuries can be examined, and (4) some specific types of injuries are so often work related (e.g., scaffold falls) as to be useful sentinels for work injury problems.

Weaknesses of hospital discharge data for work injury surveillance: (1) injury event narratives are not computerized or even centralized, (2) unlike the ANSI Z16 system, E-codes are not designed specifically to document work injuries, and (3) industry and occupation is not available, precluding the development of rates specific for risk.

Conclusion: hospital discharge data offer a useful, easy way to document severe work injuries, contrast them with nonwork injuries, and locate sentinel injuries. Hospital discharge data lack detail on work injury circumstances, occupation, and industry and therefore cannot replace analyses based on existing systems such as physicians reports, absences from work, or workers compensation claims.

Occupational Injury Surveillance Using the Alaska Trauma Registry—Husberg B, Conway G

Introduction. From 1980 to 1989 Alaska had the highest rate of any state for occupational fatalities, 34.8 deaths per 100,000 workers per year, five times higher than the U.S. average of 7.0 deaths per 100,000 workers per year. The majority of the occupational fatalities occurred in the fishing, logging, and aviation industries. The Alaska Trauma Registry (ATR) provides a population-based tool for occupational injury surveillance for moderate to severe injuries. Each hospital in Alaska participates in contributing data to the ATR.

Methods. To be included in the ATR, patients either have to be admitted to a hospital, transferred from an Emergency Department (ED) to a facility with a higher level of care, or declared dead in the hospital's ED. Data for the ATR is collected retrospectively from medical record charts and the information is sent to the Alaska Department of Health and Social Services, Division of Public Health, Section of Community Health and Emergency Medical Services to be compiled into the ATR. Data fields related to occupational injury surveillance go through additional cleaning and coding by personnel at the National Institute for Occupational Safety and Health, Division of Safety Research, Alaska Field Station. Cause of the injury can be examined via the ICD-9-CM "E-Code" and the injury description narrative.

Results. Currently the ATR has information for 20,842 cases from January 1991 through December 1995; 2,421 (12%) of these injuries were classified as occupational injuries. There are 40 fatalities among the occupational injuries (1.7%). Commercial fishing, construction, and logging led the industry categories for number of occupational injuries. The most common causes of injuries in the fishing industry were caused by machinery onboard vessel (74), fall between levels (38), and cuts (13). There are a wide variety of machines used on fishing vessels: a hydraulic lifting platform known as a crab pot launcher was the most common machine mentioned in causing injury. In the construction industry, different types of falls lead all causes with falls from or out of building or other structure (64), fall on or from ladder (43), and fall on or from scaffolding (36). The top three causes in the logging industry were being struck by an object (94), falls (33), and machinery (28).

Conclusions. The main causes of occupational fatalities in Alaska have been drowning (primarily in commercial fishermen) and trauma related to aircraft crashes. With the emphasis of the ATR primarily on non-fatal injuries, we have identified further areas of study for crab fishing injuries, falls in construction, and logging-related injuries in Alaska. As it is population-based, ATR data can be used to calculate injury incidence rates. The use of rates in injury surveillance will make the ATR data useful for industries to prioritize areas for injury prevention.

Session 15: Occupational Injuries in Automobile Manufacturing

Using Injury Surveillance and Workers' Compensation Data to Facilitate Injury Prevention Activities—Pastula S, Reeve G

During the past five years, the authors have directed an effort to design a near real-time data analysis system for occupational injuries in the North American locations of a major automobile manufacturer. The major obstacle for the project was obtaining conceptual support from certain areas within the company that did not initially accept the premise that such a data system was really needed in order to reduce injuries. This initial lack of support was based on a fundamental misconception about the utility of injury incidence data in the real-time environment of large manufacturing plants. The rationale of this misconception is best illustrated by the following statement: "You don't need a sophisticated data system to reduce injuries. You go out on the shop floor, look at the jobs, make a list of the "bad" jobs, and then fix them." However, in a plant with 3,000 to 5,000 workers, the number of "bad" jobs always exceeds the available capacity to fix them. Therefore, timely plant-based injury surveillance is critical to correctly prioritize the redesign of jobs that can or do cause injuries. Injury surveillance must include not only data about rates and types of injuries, but also cost information for all occupational injuries regardless of OSHA recordability. In addition, surveillance must continue after the "bad" job has been redesigned in order to determine: whether the changes have decreased the injuries of initial concern; and, did not result in a subsequent increase in injuries of a different type.

Several examples which illustrate the need for timely injury surveillance data in the manufacturing environment will be presented. These examples include: the occurrence of a new set of injuries

following a process change that was made to solve a specific injury problem; an effective use of injury cost data to facilitate a product design change; and, a rapid evaluation of a work-hardening program which prevented its company-wide implementation.

Fatal and Non-Fatal Incidents Associated with Forklifts and Other Powered Industrial Vehicle Incidents—Collins JW, Baker SP, Smith GS, Kisner SM, Landen DD, Warner M, Johnston, JJ

This research examines the circumstances of work-related injuries and fatalities involving powered industrial vehicles (PIVs), which include forklifts or other mobile power-driven vehicles used to carry, push, pull, lift, or stack material. Descriptive analyses were conducted on 946 PIV-related fatalities in the National Traumatic Occupational Fatality (NTOF) surveillance system from 1980 through 1993 and 916 incidents in 54 U.S. automobile manufacturing plants from July 1989 to June 1992. The NTOF surveillance system provides data from death certificates from the 50 states, the District of Columbia, and New York City. Death Certificates are collected for persons 16 years of age and older who died of external causes and for whom the certifier indicated that the fatality was associated with an injury while on the job. The automotive surveillance system is run jointly by the medical and safety departments in the plant and includes information on employee characteristics, characteristics of the workplace and injury-producing event, and description of the injury.

The three most common types of fatal incidents in the NTOF database involved PIV overturns (22%), pedestrian struck by PIV (20%), and decedent crushed by forklift (17%). The highest frequency of fatalities by industry division occurred in manufacturing (33%), transportation, communication and public utilities (16%), and construction (14%). The highest fatality rate by industry occurred in wholesale trade, mining, and agriculture/forestry/fishery. The highest forklift-related fatality rates by occupation occurred to laborers and transport operators.

The 916 PIV-related incidents in the automotive surveillance system resulted in 913 injuries and three fatalities. Of the 913 injury incidents, 41% (372 of 913) of the injuries resulted in an employee missing work. The 372 lost workday incidents resulted in a total of 22,730 lost workdays, an average of 61 days away from work per lost workday incident. The three most common types of injury incidents in the automotive manufacturing surveillance system involved pedestrians being struck by PIVs (n=35%), PIV collisions with fixed objects/other PIVs (n=16%), and mounting/dismounting PIVs (15%). Recommendations are presented with regard to the factory environment, vehicle safety features, and driver and pedestrian training for reducing the risk of powered industrial vehicle incidents.

The Incidence of Injuries Involving Robots in a Large Manufacturing Company—Pastula S, Howe J, Smitt R, Reeve G

Robots are in wide-spread use in the automotive manufacturing environment. Robots work side by side with people in the plants, and the robots are programmed and repaired by these same workers. In recent years, there has been a growing discussion of the possibility to change safety standards for robots. This discussion has been driven in large part by a presumable absence of reports of

severe injuries associated with robots. The purpose of this study was to identify robot-related injury cases among workers in a heavy manufacturing environment. In addition, the actual or potential severity was evaluated for each case.

The Ford Motor Company maintains an Occupational Health and Safety (OHS) System, which captures all work-related injuries seen at the 55 plant medical departments in the U.S. There is also a reporting tool that allows near real-time surveillance of these injuries at the plant. At the time the study was conducted, the database contained 390, 518 First-Time Occupational Visits (FTOVs) for the period June 1993 through August 1996. Of these, 200, 985 (51%) were OSHA-recordable. Text searches of the patient statement of the incident were determined to be the most accurate way to capture injuries involving robots. The first search of the database for any visit with the word "Robot" embedded in the text identified 695 injuries, 44% of which were OSHA recordable, and 53 cases had days away from work. A manual review of these cases to determine the validity of these injuries as involving robots found that a majority of the employees injured were doing manual work normally performed by the robot; working on the robot or equipment related to the robot; or, working adjacent to the robot.

Nineteen injuries actually involved being struck by the robot or pinched by robot tooling. These workers could have easily been crushed or hit hard enough to cause severe or fatal injuries. There were a significantly higher number of cases involving injuries to the eye. These were primarily due to foreign bodies in the eye caused by welding robots throwing sparks. Many of the employees reported wearing safety glasses when their eye was injured.

While the incidence of robot-related injuries is low, the potential injury severity of each of these incidents is troubling. In several of these cases had the robot rotated or extended another couple of degrees, the worker could have been killed. Under slightly different circumstances the incidents with foreign bodies in the eyes (sparks) could have caused permanent blindness. The findings of this study do not support a relaxation of current robot safety standards.

Relationship between Hand-Arm Vibration Exposure and Hand-Arm Vibration Disorders among Workers Using Impact Wrench in Automobile Assembly Lines—Jeung J-Y, Lee J-Y

This study is conducted to clarify the relationship between hand-arm vibration exposure and hand-arm vibration disorders among workers using impact wrench in automobile assembly lines.

Hand-arm vibration exposure was assessed using ISO/DIS 5349. Musculoskeletal disorders of occupational origins were assessed by the pain of hand, wrist, elbow, shoulder and low back, neck. Hand-arm disorders of vascular and sensorineural component were assessed using Stockholm Workshop hand-arm vibration syndrome classification system. The change of sensorineural component was assessed using vibration perception threshold of 8, 16, 31.5, 63, 125, 250, 500Hz.

Dominant acceleration and impulsiveness were 4.42m/sec² and 71.12m/sec² respectively and dominant frequency was 369.19Hz. Daily exposure time and year of working were 0.79 hours and 2.86 years respectively.

Prevalences and odds ratios of pain by the site of musculoskeletal system were 71.1% and 10.31 in the hand, 59.7% and 5.41 in the wrist, 53.0% and 3.65 in the elbow, 50.3% and 2.47 in the shoulder, 39.6% and 2.66 in the low back, 33.6% and 2.21 in the neck. Association between hand-arm vibration exposure and musculoskeletal disorders of occupational origin was observed. Symptom prevalences and odds ratios of vascular and sensorineural component were 51.0% and 5.24, 77.9% and 10.83 respectively. Association between hand-arm vibration exposure and vascular component, sensorineural component was observed.

Vibration perception threshold in right and left hand of the impact wrench workers by the frequency were higher than the controls. Increase of vibration perception threshold in 125, 250Hz was higher than any other frequency and this phenomenon was obvious for right hand highly exposed to hand-arm vibration. In the right hand, the trend of increase in vibration perception threshold by the frequency was observed by the increasing of sensorineural stage but this phenomenon was not observed in vascular stage. Correlation coefficient between lifetime vibration dose and vibration perception threshold by the frequency was high in all frequency and according to correlation coefficient, 63Hz was 0.68, 250Hz was 0.64, 125 was 0.62. Four hour equal energy acceleration, dominant acceleration and total tool operating time were highly correlated with vibration perception threshold of 63Hz, 125Hz, 250Hz. According to increase of lifetime vibration dose, prevalences of pain in hand, wrist, elbow, shoulder were increasing and symptom prevalences in stage of vascular and sensorineural component were also increasing.

Lifetime vibration dose will be useful index for the musculoskeletal disorders of occupational origin of hand, wrist, elbow, shoulder and the vascular and sensorineural component. Vibration perception threshold by the frequency was increasing by the increasing of lifetime vibration dose. Lifetime vibration dose will be useful to expect vibration perception threshold by the frequency and to establish preventive measures to vascular and sensorineural disorder deterioration. 63Hz, 125Hz, 250Hz will be effective frequency in measuring and following vibration perception threshold among workers using impact wrench in automobile assembly lines.

Posters

Category: Adolescent Injury

Evaluation of Occupational Diseases and Injuries Among Teenage Workers in West Virginia—Simoyi P, Islam S, Haque A, Ducatman A

Work related injuries and diseases among teenage workers were evaluated using claim databases from West Virginia Workers Compensation Bureau. All young workers who were injured between July 1, 1995 to June 30, 1996 and submitted a claim, were included in this. Data abstracted from various tables of the compensation databases included demographic variables such as age, gender, occupation, industry of employment and county of the accident. The injury information included cause of accidents, the nature of accidents, and the body parts injured. In addition, data on claim status, number of days paid for lost time and total amounts paid for lost time were also obtained. There were 2869 claims submitted

by the young workers of which 776 (27%) occurred during the months of July and August indicating peak incidents during summer period. Most of the teenagers (41%) were employed in non-classifiable establishments followed by food service industry (27%). Thirty-one percent of the young workers were classified as laborers, 8.5% as food services workers, 6.3% as cooks, and 4.8% as nurse aids. Most frequently reported types of injuries were sprains (28%) and lacerations (26%). Twenty seven percent of the teenage workers cited contact with unclassified surfaces, 5% cited the use of hand tools and another 5% cited animal bites as the cause of injury or the contact material/ equipment in use when the accident occurred. Twenty percent of all accidents involved injuries to the fingers and 14% involved injury to the back. Forty percent (1146) of the claimants received payments for lost time and the overall mean cost was \$3983 (SD=\$7264). Of those who received compensation for lost time, temporary total disability (TTD) accounted for 81% and permanent partial disability (PPD) accounted for 15% of the awards. Permanent disability is a clear issue in this juvenile workforce. Data will be further analyzed to identify specific job categories at greater risk and geographic patterns of injury distribution among the young workers. In addition, comparisons will be made with adult workers to identify specific risk factors for injuries in teenage workers.

Comparing Adolescent Occupational Injuries to Adult Occupational Injuries: Four Years' Experience of Emergency Department Visits—Marshall SW, Dufort VM, Kotch JB, Waller AE, Langley JD

Objective. This study compares occupational injuries among adolescents (ages 15-19) to occupational injuries among adults (20 years and older), presenting at a hospital emergency department, for 1990-93 inclusive.

Method. A new patient management database was used to identify work-related injuries, as well as information such as injury cause and type, injury site, age, and sex.

Results. There were 1,361 work-related injuries among adolescents and 11,002 work-related injuries among adults treated at the emergency department over the four years of the study. The injury rate per 200,000 hours worked (100 full-time equivalents) among adolescents (13.8/200,000 hours) was more than double the rate among adults (6.3/200,000 hours). Adolescent males had a rate of 20.6 injuries, and females 5.8 injuries, per 200,000 hours. Adult males had an injury rate of 8.5 injuries, and females 2.6. Comparing injury rates between adolescents and adults, adolescents had remarkably higher injury rates for upper extremities (7.8 vs 2.7 per 200,000 hours), head injuries (3.2 vs 1.7 per 200,000 hours) and lower extremity injuries (2.2 vs 1.2 per 200,000 hours). Upper trunk injuries and systemic and special injuries are similar between the two groups. While overall injuries occur more frequently among males than females in both age groups, the disparity is slightly less among adult workers.

Conclusion. These findings point to the different risks and needs for prevention and treatment of occupational injury among adolescents compared to adults. This study also demonstrates how a well-planned data collection system can overcome some of the previously described difficulties of getting prevention-oriented information from emergency departments.

Adolescent Work-Related Fatalities—Kentucky 1994-1995—Moon E, Scheerer A, Struttman T

Adolescents constitute a special population of the work force. Four adolescent fatality cases extracted from data collected by the Occupational Injury Prevention Program of the Kentucky Injury Prevention and Research Center will be presented as case studies of adolescent work-related fatalities. For inclusion, cases must meet the following criteria: (1) Victims were less than 18 years of age; (2) incidents occurred in Kentucky; (3) victims were residents of Kentucky; (4) incidents occurred in 1994 or 1995; and (5) incidents occurred during the performance of productive work, either volunteer or for remuneration. Cases to be presented are: (1) A 15-year-old boy working in a tobacco field, killed when his tractor turned over; (2) a 16-year-old boy delivering newspapers, who died of head injuries received in a motor vehicle crash; (3) a 14-year-old boy who was assisting a logger, crushed by a falling tree; and (4) a 17-year-old boy installing exhaust fans in a church, who was electrocuted.

Risk factors identified include lack of experience; lack of training for task as well as occupational safety and health training; lack of supervision; inappropriate size/strength for performing task; adolescent maturity/judgment level; fatigue; and time constraints. Recommendations for prevention are suggested, including task restriction; equipment modification; required use of personal protective equipment or systems; job training; and supervision.

Category: Agriculture

Fatal Injuries in Iowa Related to Loading Equipment—Johnston W, Rautiainen R

A significant portion (14 out of 156, or 9%) of Iowa FACE fatalities during 1995-1997 have been related to loading equipment: front-end loaders on tractors, skid-steer loaders, or front forks on these machines. Causes of injury include loader buckets falling on persons working under them, workers getting crushed between a stationary object and the loader, materials falling from the loader, and loaders overturning due to a high center of gravity while lifting or moving loads. Construction and agricultural loading safety needs specific attention due to the large number of serious injuries. The Iowa FACE program has produced materials to address these hazards and continues efforts to reduce loading injuries. Following are brief summaries of four representative case investigations:

A 37-year-old farmer was trying to clean the operating pedals of a skid-steer loader, which were frozen with manure, snow, and ice. He was working in a cold, small garage with a low ceiling, which prevented using the machine's lift arm locks. The bucket was stuck in the 3/4-raised position. The victim had disabled the seatbelt safety interlock and the bucket came down on him when he loosened the pedals and hydraulic linkages with a crowbar.

Victim was a 75 -year-old farmer working alone loading manure with an older narrow-front tractor equipped with a front-end loader. Working in a sloped barn yard, he was moving in a reverse turn with the bucket raised, and full of manure. The tractor was tilted to the side and to the front, increasing its instability, and it tipped

over during while turning. It rolled completely over crushing and killing the farmer.

A 61-year-old farmer and retired maintenance worker was in process of cutting trees and moving logs. Victim was using a backhoe with front-end loader to position a cut tree onto a wood pile, using the bucket to pick up a large tree with many limbs intact. The tree rolled off the bucket and a branch hit the farmer in the face and neck. He was found pinned in the tractor seat. CPR was ineffective.

A 51-year-old farmer's wife was helping her husband and son construct a new house on their farm. She and her son were standing between the tractor loader bucket and the house foundation holding down drainage tiling while the son filled in with gravel from the bucket. When the husband raised the front-end bucket to dump the load, they became pinned to the foundation. The farmer suspects brake failure, however our investigation shows other significant factors in loader geometry. The farmwife died of a ruptured aorta.

The 14 cases involve several recurring hazards which we will discuss: changes in center of gravity with loader position, type of machine, and nature of work; dangers of moving or working under hydraulically-controlled buckets or forks; improper use of skid-steer loaders; front-end loader use in tight spaces; and dangers from lifting loads over-capacity.

***ATV Injuries and Fatalities in Agriculture in Nebraska*—Hetzler B**

Problem Statement. In Nebraska we had five agriculture related All Terrain Vehicle (ATV) fatalities in 1996. Four of these were on-the-job (all adults) and one was recreational (nine-year-old). With four (8%) of the 48 occupational fatalities in Nebraska in 1996 being ATV fatalities, this was cause for concern.

Method. I have collected data on the fatalities and received accident reports on all ATV accidents reported to the Department of Roads for 1996 (28 reports). An ATV survey has been prepared to send to different groups throughout the state. The director of the 4-H Program for Nebraska is distributing a sample of 2,500 surveys to 4-H clubs throughout the state. The survey will also be completed by youths attending approximately 25 summer agriculture camps sponsored by the Nebraska Department of Health. Surveys will also be available at booths at County Fairs and special agriculture events such as tractor training for youths. The Nebraska Cattleman's Association has also agreed to publish the survey in their magazine (circulation 9,500). A 1-800 number is included with the magazine version of the survey.

This survey covers how ATV's are used; age and gender of operator; size of ATV; type of ATV (3-wheel, 4-wheel or other) protective gear worn; operating environment (paved/unpaved surface); and accident experience (to include if accident resulted in: restricted work activity, medical attention required or loss of consciousness). Also information about a free ATV Rider Course, provided nationwide, is being included with the survey.

Results and conclusions will be formulated when surveys are reviewed. After this review we will determine the best avenue to pursue to reduce ATV injuries and fatalities in agriculture. We began distributing surveys in late May, 1997, and will continue through the summer of 1997.

Also available at the poster will be copies of the ATV Survey and safety flyers we developed and disseminated on ATV fatalities and other agriculture fatalities.

***Occupational Injury in Migrant Hispanic Farm-Worker Families*—McCurdy SA, Beaumont JJ, Wilson BW, Henderson J, Samuels SJ, Schenker MB, Morrin L, Carroll D**

Background. Injury represents an important health and economic problem in the agricultural industry. Although an important body of research has accumulated for injury among farmers and agricultural workers in other areas of the U.S., few data are available for migrant farm workers. There are approximately 3 million migrant and seasonal farm workers and dependents in the U.S., and estimates of the population in California range from 600,000 to 1.2 million. Farm workers tend to belong to ethnic and linguistic minorities. The predominant ethnic group is Hispanic, and in California this group constitutes approximately 90% of migrant and seasonal farm workers.

Farm workers may be at increased risk for injury because they are most immediately involved in production tasks. Hazards include animals, machinery, chemicals, and dangerous environmental conditions. Contributing factors in this population include low educational status, poor English and literacy skills, and inadequate understanding of existing reporting and support structures such as Workers' Compensation. Finally, agriculture is unusual among industries in that law and custom allow family labor, putting children at risk for farm-related injuries.

Methods. We are conducting a prospective cohort study of occupational injury among 500 Northern California migrant Hispanic farm worker families comprising approximately 1000 adults and 700 children. The study addresses specific hypotheses regarding remediable risk factors for injury. These include organophosphate pesticide exposure, piece-work vs. hourly pay, language appropriate safety training, and the role of multiple employment. Subjects live in local government-supported migrant housing centers. The population is overwhelmingly Hispanic and Spanish-speaking. Participants complete an interviewer-administered work-and-health questionnaire at the beginning of the harvest season (April-May 1997) and a baseline acetylcholinesterase test. Subjects are contacted approximately every 4-6 weeks through the remaining harvest season to determine work exposures and injury experience. In September and October 1997, a final interview is conducted, and subjects provide an end-of-season acetylcholinesterase test.

Results. At this writing, we have completed initial interviews on 717 adults, yielding a participation rate over 85%. Of these, 52 (7.3%) reported qualifying injuries within the preceding year. Among 575 children, 19 (3.3%) reported a qualifying injury within the preceding year. Further information will be available and presented at the symposium.

The Populations of Those Injured on Family Farms in Central Wisconsin—Stueland DT, Lee B, Gunderson P, Wittman L, Layde PM, Nordstrom DL

Farming is one of the most hazardous of all occupations. Few studies have been able to evaluate the incidence and risk factors for farm residents.

The Marshfield Epidemiologic Study Area (MESA) offers an unique opportunity to do a population-based case-control study of agricultural injuries. MESA contains a population of 49,186 of whom 4,828 are farm residents. Active agricultural surveillance continues in this population. During a two year period, cases were identified for a case-control study.

Overall, there were 472 injuries of which 183 (38.8%) occurred to nonfarm MESA residents. For farm residents, numbers of injuries and injury rates per 1,000 person years, with 95% confidence limits, were calculated. There were 207 injuries to adults, age 18 to 64, with a rate of 37.6 (32.8, 43.1). Children, age less than 18, suffered 58 injuries with a rate of 17.7 (13.6, 22.8) while elderly, age 65 and over, had 27 injuries for a rate of 31.1 (21.3, 45.4). Adult males (N=191) had a rate of 55.7 (48.1, 64.2). The injured included 28 persons with previously identified learning disorders of whom 14 (50%) were farm residents.

Residents of dairy farms had an injury rate of 35.2 (30.4, 40.8) while residents of nondairy farms had an injury rate of 14.1 (9.1, 22.0).

There was a wide spectrum of severity of injuries. During the period of observation there were two deaths, both of which occurred to nonfarm residents. Among farm residents, 8% of those injured were admitted for further treatment.

The major agent of injury was animals although injuries were also seen due to falls and machines. The most significant single risk factor for injury was hours of work which increased the risk of injury 3% per hour worked.

Family agricultural production involves not only adult males and females but also children and elderly. Interventions to reduce the rate of injuries to farm residents need to address the populations at risk and the diverse agents of injury.

National Estimates of Eye Injuries Based on the Traumatic Injury Surveillance of Farmers Survey—Walker F, Myers J, Geidenberger C

Little information regarding the incidence and risk factors for agricultural eye injuries in the U.S. is available. Data from the Traumatic Injury Surveillance of Farmers (TISF) were used to generate weighted national estimates of the incidence of eye injuries occurring on U.S. farms and ranches as well as to characterize those at highest risk. The TISF survey examined self-reported work-related injuries from a random sample of agricultural operations during the period of 1993-1995. The mail-based survey obtained information on injuries that either caused the injured person to seek medical attention or restricted activity for one-half day or more. It

was designed to sample all 50 states by the end of the 3-year period.

Preliminary data from the 1993 TISF survey of 20 states indicated that eye injuries represented 6.7% of all agricultural injuries reported in the survey. From the 33 reported eye injuries, it was estimated that a total of 13,512 eye injuries occurred on U.S. farms and ranches in 1993.

For all lost-time injuries in the TISF, males accounted for 90.3% of estimated cases, and for eye injuries males represented even a larger percentage (98.3%). The greatest distribution (46.8%) of the eye injuries occurred in workers 20-29 years of age, but no eye injuries were reported for those under 20 years. The majority of the injured were non-Hispanic whites (66.6%) or Hispanics (29.7%). In the TISF survey, 63% of all lost-time injuries occurred to family workers (operators, partners and their families) compared to 37% for hired workers. However, 60.7% of eye injuries were reported for hired workers. Sixty-five percent of eye injuries occurred during the summer months (May-August). All of the reported eye injuries required medical attention but none resulted in permanent disability.

The distribution of total eye injuries by the activity when the injury occurred was as follows: farm maintenance (17.8%), machine maintenance (16.7%), handling livestock (14.5%), handling or storing crops (11.1%), or field work (10.0%). The object that caused the eye injury was a power tool (21.9%), hand tool (15.2%), livestock (14.0%), plants or trees (13.6%), truck/auto (3.3%), working surface (2.5%), or other source (27.6%). Pesticides or chemicals accounted for only 2.0% of the eye injuries. The proportion of eye injuries to all types of agricultural injuries differed according to the type of operation. For example, 32% of injuries in nursery operations were eye injuries, compared to 3.6% for field crop, 4.4% for vegetable, fruit or nut, 5.3% for beef, hog or sheep, and 7.0% for dairy operations. No eye injuries were reported in this limited sample for poultry or other farming operations.

Since eye injuries are largely preventable, these data may give direction for identifying certain agricultural tasks and specific agricultural operations to target for more intensive surveillance efforts and intervention research.

Category: Construction

Effects of a "Back Care" Program in Construction—Marks N

A population of 48 construction workers with prior history of disabling low-back pain were involved in an education and exercise program aimed at reducing recurrence of disability. They were followed for 4 years post-training and their injury experience and pain ratings were reviewed.

Although limited by the sample size, the findings showed that there appears to be a positive effect on the workers' ability to manage their pain better and to prepare themselves for strenuous activity by using the exercises taught during the program.

Construction Safety Association of Ontario Occupational Injury Database—Hardy F, Eng P, McVittie D

CSAO has been compiling injury data drawn from WCB records for many years. The Injury Database (INJ) records have several fields which are not normally resident in most insurance or WCB datasets in other jurisdictions.

In addition to the common “name, rank and serial number”-type of data, CSAO’s system captures data on project-type, construction activity type, specific worker occupations including apprentice or supervisor/foreperson status, worker activity, working surface, condition of working surface, major and minor codes for part of body, type of accident event, type of injury, distance and weight. In addition, 3 fields are available to record the materials, tools or equipment involved in the accident event using fields “Acted on”, “Acted with” and “Other Involvement”. A 3 line full text description is available as well as compensation, medical aid and pension costs.

This data is used to conduct injury analyses for different occupational groups or for different sectors of construction. The most comprehensive use of the data system has been the production of the Injury Atlas, which examine the injury experience of over 20 specific occupations in construction. Sample sets of data from the Atlas would be presented and discussed.

Hand Protection for Drywall Installers and carpet layers—Hardy F, Eng P

Research into serious cuts in the drywall sector of construction showed that the most serious injuries were the result of cuts affecting the tendons and the palm of the hand. Testing showed that weight lifters gloves could provide adequate protection of these areas and still permit an adequate level of dexterity for picking up screws, nails and other small items. Work with apprentices in this sector showed that early exposure to this solution is important in getting acceptance of this change in work practices.

Issues relating to GFCI usage with portable generators—Hardy F, Eng P

Questions regarding the grounding of portable generators and the issue of Ground Fault Circuit Interruptor performance led CSAO to carry out testing during April '97. There are concerns that without grounding the use of GFCI's is ineffective. Grounding the generator without using the GFCI would present a risk of electric shock since the user of the tool would have a voltage potential difference with earth. If the generator is not grounded to earth, however, there are some people who suggest that this is safer than grounding since the user would not have a voltage potential difference with earth and therefore would be safer.

In order for an electric shock to be experienced by the user of an ungrounded generator, a phase to phase fault would have to occur. This is much less likely than a phase to ground fault.

Leakage currents necessary to trip GFCIs were created and measured with different grounding configurations on the generator(s). Data on configurations and leakage currents would be presented.

SAFE-TRACK - Uniform Injury Tracking Process—Martin J

SAFE-TRACK is a computer-based system that records injury incidents in the construction, industrial and commercial industry sectors. The resulting data is then interpreted utilizing focus groups of workers along with safety professionals and used to recommend specific targeted actions to provide for increased worksite safety. Follow-up SAFE-TRACK data is then reviewed to evaluate the effect of the targeted worksite changes.

In addition to tracking injuries to establish industry or company baselines, SAFE-TRACK data has been used successfully in more than 25 projects to improve safety concerns at construction worksites, often during the progression of the work.

SAFE-TRACK's tightly targeted injury information has proven to be a valuable tool in assisting construction companies, as well as their health and safety focus groups, in designing and implementing continuous safety improvement programs which result in measurable decreases in OSHA recordables and lost-time accidents.

SAFE-TRACK is a system that provides focused safety trend analysis for users of construction services, contractors, as well as the crafts. The injury information, easily collected on a simple form, is indexed by OSHA injury severity classifications and reports can be produced by project, by craft worker, by type of injury, by shift, or by time of day; as well as other user requested formats.

The use of SAFE-TRACK provides a uniform reporting source, from job to job, from year to year, that establishes a statistical tracking system supporting planning issues that can include:

- * Focused and measurable modifications in safety measures
- * Cost effectiveness analysis of incentive safety programs
- * Analysis of the long term effect of work practices on safety trends
- * Analysis of trends in project injuries, often reflected in insurance costs.

Falls Profile of Construction Laborers—Akladios M

This poster summarizes major causes and circumstances for fatal falls among construction laborers. The primary information in this profile was generated by data from the Bureau of labor Statistics Census of Fatal Occupational Injuries.

Additional information is generated from NIOSH Fatal Accident Circumstance & Epidemiology Analysis. FACE reports are detailed reports performed by NIOSH. While FACE summaries do not provide solid statistical explanations, they help explain factors that may be overlooked by comprehensive statistical data bases such as CFOI.

Ratios were calculated by comparing data generated by the CFOI database to full-time employee totals generated by the Center to Protect Workers' Rights (CPWR). The analysis covered deaths that occurred in the labor industry during 1992-1994.

The analysis showed that in the Laborers' profile, CFOI code 879, the number of fatalities was found to be 156.

Results from CFOI and FACE showed that most fatalities occurred to males within the age range of 25-44, and that all laborers lost their lives within four days of falling. Most of them hit concrete surfaces, head first.

From FACE summaries, the most common violations were 29 CFR 1926.104, 105, and 451.

Recommendations included: 100% tie off, covered/marked man-holes, skylights, and other roof openings, the utilization of nets, and extensive employee training.

***Questionnaire-based Ergonomic Hazard Assessment of Construction Workers with Musculoskeletal Injuries*—Anderson J**

Since 1990, we have conducted surveillance of construction worker injuries treated in George Washington University's Emergency Department. Musculoskeletal injuries were the second-most prevalent type of injury, accounting for 21% of these emergency department cases. Since June 1996, we have telephoned workers to collect details on the injury circumstances as well as return-to-work programs, ongoing musculoskeletal symptoms, and subsequent or recurrent injuries. By interviewing workers from a number of construction trades, we hope to characterize both the short- and long-term effects of these WMD injuries on physical health, emotional health, and livelihood.

One of the questions in the telephone interview addresses day-to-day trade-specific tasks. The nature and frequency of the most common tasks were identified for each worker. From initial interviews to date, we generated a preliminary listing of the tasks reported by two trades — carpenters and plumbers. From this list, we standardized and coded the tasks for the two trades. For each standardized task, we used available data (trade-specific ergonomic analyses, checklists, expert opinion, etc.) to produce a trade-specific ergonomic hazard rating that addresses posture, force, and repetition. Once an ergonomic hazard rating was developed for each task, the ratings were weighted by frequency and summed across the identified tasks for each worker.

This paper will focus on the methods for developing individual ergonomic hazard ratings from questionnaire-based data on tasks. We plan to develop similar trade-specific task-based ergonomic hazard ratings for all workers in our followup study.

These task-specific hazard ratings will enable us to compare the ergonomic hazard in the WMD-injured population to that of an age- and trade-matched comparison population who were asked the same question about their daily tasks. When the analyses are complete, we hope to have determined: (1) whether the level of ergonomic hazard influences the occurrence of ongoing musculoskeletal symptoms and subsequent or recurrent injuries; and (2) whether any specific tasks or ergonomic factors appear to put workers at risk for ongoing symptoms or recurrent WMD injuries.

***Construction Injuries in Alaska*—Husberg B, Conway G**

Introduction: Construction takes place year 'round in Alaska, and the harsh arctic environment introduces factors that can interfere

with worker safety. This study uses injury surveillance data from the Alaska Trauma Registry (ATR) to examine injuries in the construction industry.

Methods. Data from the ATR for the years 1991 - 1995 was used to characterize the causes of injury in the construction industry in Alaska. The ATR is a statewide, population-based data base that tracks moderate to severe injuries that occur in Alaska. Data is collected retrospectively from hospital medical records at each hospital in Alaska, then sent to the Alaska Department of Health and Social Services, Division of Public Health, Section of Community Health and Emergency Medical Services to be compiled into the ATR. Occupational injury surveillance data goes through additional data cleaning and coding by personnel at the National Institute for Occupational Safety and Health, Division of Safety Research, Alaska Field Station. The ATR only includes those moderate to serious injuries which require hospitalization. The only fatalities that meet the case definition for inclusion into the ATR are those who have been seen and treated in a hospital prior to death.

Results. The total number of hospitalized injuries in the construction industry ranked second (n=371) in number only to commercial fishing (n=396). Six (1.6%) of the construction injuries resulted in fatalities. There was a mean of 74 injuries each year in the construction industry ranging from 66-88. Falls lead all other causes of injury, accounting for 198 of the cases. The most common falls are from or out of a structure (67), while using a ladder (52), while using scaffolding (36), from one level to another (18), and slipping or tripping (10). The upper extremities are the most common body region injured followed by the head. The most common injury is a musculoskeletal injury - usually a broken bone. There is no pattern suggesting a seasonal variation to falls. It is not possible to reliably ascertain from ATR abstracts if the fall was directly caused by ice or snow.

Conclusions. Previous studies have ranked occupational fatalities in the Alaskan construction industry in the bottom third. However, construction injuries rank second in number of all industries recorded in the ATR. Even though construction continues year round in Alaska, our data show no consistent pattern suggesting an increase of falls when arctic conditions are present. From these data, further research into fall prevention and protection in the Alaskan construction industry is currently underway by a interagency working group in Alaska.

Trade-Specific Injury Patterns among Construction Workers

Nessel-Stevens L, Hunting K, Welch L

In order to learn more about the causes of non-fatal construction worker injuries, we established an emergency department-based surveillance program. Between November 1990 and June 1996, we reviewed the medical records of 2,280 construction workers who have been treated in the GWU Emergency Department for work-related injuries and illnesses. These injured workers were overwhelmingly (98%) male, and most (66%) were between the ages of 25 and 44. Laborers, carpenters, and electricians led the list of occupations, though workers from over twenty construction trades were represented. The most common injuries treated were lacerations (38%) and strains and sprains (21%). Four percent of the workers had injuries serious enough to require hospital admission. Contact with sharp objects (28%), falls (16%), and overexer-

tion (11%) were the most frequently noted injury circumstances.

While the overall demographic characteristics, diagnoses, and injury circumstances are interesting, it is the more detailed injury descriptions, by trade, that are more useful for thinking about injury prevention. To illustrate this, we will present data on injury patterns among workers from four specific trades: carpenters; electricians; ironworkers; and plumbers and pipefitters. Together, these trades represent 43% of the injured construction workers in our case series. Highlights of the results follow:

Lacerations were the most frequent injury for each of the trades except for ironworkers, and for all trades combined. For ironworkers, sprains, strains, and muscle pain was the most frequent injury category, especially to the back and ankle or foot.

Among carpenters and plumbers, lacerations were most often caused by pieces of metal or unspecified metal objects. Power saws, drills, nail guns, and screw guns were also frequently associated with carpenters' lacerations. In contrast, electricians most often sustained lacerations while fixing or changing light fixtures, while ironworkers were most frequently cut by tie wire.

Ironworkers experienced a higher proportion of falls than any other trade examined in this study. Slips/trips (many while walking on rebar) were the most frequent type of fall sustained by ironworkers. In contrast, among plumbers, electricians, and all trades combined, falls from ladders represented the most significant fall hazards.

These and other differences in injury patterns allow us to discern specific risk factors for construction work injuries, and to suggest prevention measures that might be implemented on a trade-specific and task-specific basis.

A Tool for Planning and Monitoring Construction Site Safety

Gambatese JA, Hinze JW

Ensuring safety on the construction site involves careful planning and implementation of safe practices and procedures. Project safety planning involves anticipating safety hazards and applying effective safety measures to the job at hand in order to minimize or eliminate the hazards. Effective safety planning relies on one's knowledge of construction processes and procedures and the applicable safety regulations. Safety planning is enhanced when assistance is provided in determining the safety regulations applicable to each construction process and procedure. Following the safety planning effort, successful implementation of safety measures requires periodic inspections of the jobsite to ensure the safety plan is in place and safety regulations are met. While safety inspections are a valuable means of maintaining a safe jobsite, the complexity associated with many construction projects can cause some hazards to be overlooked. Many construction firms utilize safety checklists to assist in performing safety inspections.

A computer program has been developed to assist in planning and monitoring construction site safety practices and conditions. The program includes a database of construction safety checklists that address various general requirements, work phases, temporary structures, and construction materials. Instead of creating generic checklists, the program allows the checklists to be modified to match the specific jobsite characteristics. The checklists related to specific

work phases can be useful in planning and scheduling safety measures before construction begins. During construction, the checklists can prove useful for jobsite inspections by safety personnel, safety committees, and others involved in monitoring safety conditions on a jobsite. In addition, the checklists also provide valuable information that is useful in safety training.

Mortality Patterns Among the International Brotherhood of Electrical Workers, 1982-87—Robinson CF, Petersen M, Palu S

This study evaluated the mortality of 31,068 members of the U.S. Electrical Workers' Union who worked in the construction industry and died 1982-1987. Age-adjusted proportionate mortality ratios (PMRs) and proportionate cancer mortality ratios (PCMRs) were computed using the U.S. age-, gender-, and race-specific proportional mortality for the years of the study. For white male electrical workers, significantly raised mortality was observed for lung cancer (PMR=117), mesothelioma (PMR=356), melanoma skin cancer (PMR=123), cancer of prostate (PMR=107) leukemia (PMR=115, tumors of eye, brain and central nervous system (PMR=136), diseases of the blood forming organs (PMR=141), asbestosis (PMR=248), electrocutions (PMR=1145), and all fatal injuries (PMR=116). When proportionate cancer mortality analysis was used, the risks for these cancers remained elevated, although the significance became borderline for leukemia and melanoma PMRs. Among 114 white women electrical workers, mortality due to leukemia (PMR=195) and breast cancer (PMR=124) was elevated, but not significantly. More than 82% of all electrical workers studied had greater than 30 years membership in the union. The data show that electrical workers have elevated proportionate mortality for the diseases caused by asbestos (lung cancer, asbestosis, and malignant mesothelioma) and from traumatic injuries, particularly electrocutions and other fatalities that may be related to the workplace. The findings of prostate cancer, tumors of eye, brain and central nervous system, and diseases of the blood forming organs were unexpected. Elevated mortality from leukemia and melanoma skin cancer may be related to electrical work and suggests further evaluation of possible risk factors is needed. These data suggest that construction electrical work is a very hazardous trade.

Motor Vehicle Fatalities in the United States Construction Industry—Fosbroke DE, Ore T, Hixon P

A death certificate-based surveillance system was used to identify 2,144 work-related motor vehicle fatalities among civilian workers in the United States construction industry over the years 1980-92. Construction workers were twice as likely to be killed by a motor vehicle as the average worker, with an annual crude mortality rate of 2.3/100,00 workers. Injury prevention efforts in construction have had limited effect on motor vehicle-related deaths, with death rates falling by only 11% during the 13-year period, compared with 43% for falls, 54% for electrocutions, and 48% for machinery. In all industries combined, motor vehicle fatality rates dropped by 47%. The largest proportion of motor vehicle deaths (40%) occurred among pedestrians, with construction accounting for more than one-fourth of all pedestrian deaths. A minimum of 54 (6%) of these pedestrian fatalities were flaggers or surveyors. Flaggers accounted for half the 34 pedestrian fatalities among women, compared with only 3% among men. Along with previous studies and recent trends in the amount and type of road construc-

tion, these results underscore the need for better traffic control management in construction work areas to reduce pedestrian fatalities. As the second leading cause of traumatic death in construction, with an annual average share of 15% of the total deaths, exceeded only by falls, prevention of work-related motor vehicle research should become a greater priority in the construction industry.

Category: Engineering and Protective Technology

Near Fatal Events—Momentary Lapses in Reason?—Stobbe TJ, Cormier W, Monteressi C

Every day people die in the workplace. Many of the deaths occur when highly experienced people who knew better, select actions that put them at high risk of serious injury or death. The question is WHY? Are they careless? Ignorant? Risk takers? Indifferent? This paper discusses the why by summarizing the results of 134 structured interviews of workers who had been involved in incidents that could have been fatal for them.

The purpose of the project was to understand why these incidents occurred so that intervention strategies could be developed. The interviewees were experienced coal miners at underground and surface coal mines. One or more of the authors conducted the interviews, and they lasted one to one and one-half hours. The interviews were conducted at the worksite. The focus of the interviews was to understand both what happened during the incidents, and the interviewee's role in the incident. Once these were understood, the interviews focus shifted to trying to understand WHY what happened happened—both in the global incident, and in the actual actions of the interviewee. We were particularly interested in the interviewee's actions and the judgements that led to the actions and outcomes.

The results show that the data fell into six categories. The categories were: following orders, conscious choice, making assumptions about the state of the world, did not know the risk, were "unconscious" at the time of the incident, and deliberate risk taking. Each of these categories suggests a different combination of intervention strategies. For example, when a worker is following a supervisor's orders when they make unsafe behavior choices, it is primarily a management problem which may be addressable through supervisor training—or it may take a complete change in corporate philosophy about the comparative importance of safety and production. In comparison, a worker who does not know about a risk may need to be educated about the hazards and risks that exist in his/her workplace with classic cognitive training methods.

The paper discusses each of the six behavior categories, gives examples of each, and discusses ways in which the "safety" problems associated with each category may be addressed. It also discusses an intervention project that is being developed to address some of the categories.

An Ergonomic Audit of a Mississippi River Revetment Process—Chervak SG

An ergonomics team from the U.S. Army Center for Health Promotion and Preventive Medicine performed an assessment of a Mississippi River revetment operation.

Revetment is the process used to reinforce riverbanks with concrete plates to combat erosion. The task is unique, but the ergonomic risk factors involved are fairly typical.

The ergonomics team identified specific ergonomic hazards that can contribute to cumulative trauma disorders, resulting in decreased productivity, increased errors, lost work time, and increased costs. Tasks at the revetment operation included facilitating the removal of concrete slabs from a storage barge, aligning the slabs onto the roller barge, straightening the slabs as needed, and tying together the concrete slabs using a pneumatic tying tool. The risk factors identified included awkward postures, forceful exertions, mechanical stresses, and repetitive motions. Recommendations to reduce the risk of suffering a cumulative trauma disorder injury included modifying the tying tool to minimize poor back postures and to eliminate the amount of repetition, reducing force required to operate the tool, and eliminating mechanical stresses. The ergonomics team also recommended that the operation be examined to determine if certain jobs in the process can be eliminated and that employees be educated in the proper use of the tying tool.

Development of a Data Collection System for a Pen-based Computer—Ching CR

To facilitate the recording of survey information, an ergonomics team from the U.S. Army Center for Health Promotion and Preventive Medicine developed a data collection system for use with a pen-based computer.

The team had to evaluate video display terminal workstations at U.S. Army installations in Belgium and determine compliance with Belgian Royal Decree. In addition to the Decree, the team used International Standards Organization and European Community standards to research evaluation criteria. The survey involved three pen-based computers, each running the same software program. The team wrote a data collection program with the interface designed to take advantage of pen-based computer features. Five evaluators received training in the use of the pen-based computers. Evaluators entered information, such as features of the individual workstation and environment, and recorded potentially damaging postures. The multilingual system gave immediate feedback and "quick-fix" recommendations for each workstation. The team evaluated 340 workstations within a 15-day period with each survey lasting approximately 10 minutes. The team downloaded survey results from each pen-based computer to create one large data base for analysis. The data collection system was efficient and easy to use. The team will modify or customize the program for other applications.

Hazards Associated with Roof Drilling and Bolt Installation in Underground Coal Mines—Unger RL, Cornelius KM, Turin FC

Roof drilling and bolt installation in underground coal mines is labor intensive, repetitive, and exposes operators to many hazards which can result in accidents, both acute and cumulative in nature. One concern of mine safety officials is the number accidents occurring where the roof bolter operator is crushed by the powerful hydraulic drill boom. Another concern is the rising number of injuries due to cumulative trauma. A NIOSH team of researchers examined these problems with several goals in mind. The first was to identify the root causes of the acute trauma accidents and de-

velop effective solutions that could be implemented promptly. The second goal was to examine the cumulative trauma exposure of roof bolter operators and develop recommendations aimed at reducing the risk of developing injuries. Finally, the team developed materials to educate the mining industry on human factors engineering principles with the intention of improving the design of roof bolting machines.

The following steps were taken to investigate traumatic crushing injuries: interviewed roof bolter operators, analyzed video tapes of roof bolting operations, discussed issues with roof bolter manufacturers, analyzed mine accident data, and reviewed past research on roof bolter safety. The team determined that the goal of any intervention should focus on reducing the probability of a control being accidentally activated and reducing the chances of roof bolter operators placing themselves in hazardous positions around the machine. To achieve that goal, the team developed a list of solutions based on their analysis of the information collected. Some of the recommended solutions include the use of an operator-in-position interlock device, fixed barriers at pinch points, improved control guarding, and reduction in speed of the fast feed. Many of these ideas have already been implemented.

In response to cumulative trauma exposure concerns, members of the project team conducted a study at an underground coal mine to examine roof bolter tasks that performed over time could put the operator at risk. For this study, three primary forms of data were collected and analyzed. Researchers analyzed 43 lost time incident descriptions, conducted a series of interviews with roof bolter operators, and observed operators performing roof bolting tasks. Common roof bolting activities were examined and issues identified as putting operators at risk of injury were discussed. Recommendations were developed which address the three elements which define a system: human, equipment, and environment. The recommendations can be used to increase worker awareness of risk factors, modify job procedures, improve existing equipment, and provide guidelines for future equipment design.

Efforts to educate the mining industry have included the development of seminars on human factors design geared toward design engineers and mine safety personnel, the construction of mockups that demonstrate human factors principles, and the publication of a world-wide-web page devoted to human factors design issues associated with mobile underground mining equipment.

Safety Considerations for Transport of Ore and Waste in Underground Ore Passes—Stewart BM, Beus MJ, Iverson SR, Moreland MW

Researchers at the Spokane Research Center of the National Institute for Occupational Safety and Health are investigating methods to improve safety during transport of ore in underground mines and to prevent injuries and fatalities to miners around ore passes. Five fatalities in the last three years were directly related to ore hang-ups resulting in ore pass structural failure and ore chute blow-out. Mine Safety and Health Administration (MSHA) accident statistics have identified ore pass hazards. Mine accident data has shown that injuries and fatalities have resulted during ore pass chute and gate operations. Nearly 75% of the accidents related to pulling or freeing ore pass chutes are caused by the use of hand tools and falls of broken rock. Recent ore pass failures have underlined the need for improved designs, standards, structural monitoring meth-

ods, and improved hang up prevention/removal techniques. A fault tree analysis identified five leading causes of ore pass failure. Ore pass transport practices and problems at past and present operating mines are discussed.

Design criteria and hang up prevention and remediation strategies include effects of static and dynamic ore and waste rock loads on chutes, walls, gates, and support structures. Particle flow analysis methods were used to simulate the response of various ore pass designs to a wide range of ore loading conditions. A full-scale and 1/3 scale mock-up of ore pass and chute assemblies currently installed were duplicated and tested for load response. Data from the particle flow code, and the mock-ups are compared. Instrumentation and load measurements of an active ore pass will be conducted after the mock-up tests are completed. Development of safer ore pass design and ore handling procedures are the goals of the project.

Graphical Analysis of Energy Expenditure—Belard J-L, Dotson B, Wassell JT, Long D, Wojciechowski W

Waste abatement workers, due to the nature of their job, require a high level of protection and must therefore commonly wear personal protective equipment such as a self-contained breathing apparatus (SCBA) and encapsulating suits. Wearing this type of personal protective equipment while working adds a weight burden, impedes heat exchange and can lead to physiological strain and increased energy expenditure. This strain and increased energy expenditure can in turn lead to exhaustion in a period of time much shorter than would be experienced without this equipment. The goal of this study was to analyze the energy expenditure of hazardous waste abatement workers while performing tasks common to their jobs.

Nine asbestos workers aged 27 to 40 performed six typical hazardous waste abatement tasks in a laboratory setting. Subjects carried an SCBA and wore a Mine Safety Appliances Company (MSA) BlueMax™ totally encapsulating suit. This level of protection is designated "Level A" and is utilized by workers who require the ultimate possible protection during waste site cleaning operations. Although all subjects were in a safe laboratory environment, they were required to wear this complete protection in order to approximate work site energy expenditures. However, since no activity in a toxic environment was involved, subjects were allowed to keep the garment open and the SCBA disconnected. All tests were conducted in a neutral environment (20°C Centigrade, 60% relative humidity). Heart rate, respiratory frequency, and oxygen consumption were measured every 30 seconds during the performance of the various activities.

Six different tasks were selected for simulation through an agreement with hazardous waste abatement union experts. The activities simulated typical tasks performed daily on hazardous waste sites. These typical tasks included: walking from one place to another, carrying equipment, decontamination of soiled surfaces, shoveling toxic dirt into drums, digging to uncover barrels, and crawling in confined spaces. These tasks were simulated with the following activities: walking on a treadmill at 1.5 miles an hour, carrying a 20-pound bucket at the same speed, mopping the floor at 60 strokes per minute, shoveling sand from ground level into a drum, digging at ten shovels per minute, and crawling on the treadmill at 0.3 miles an hour. In all, each tested activity lasted ten minutes, including a

five minute warm-up that allowed each subjects' heart rate to reach a plateau. Oxygen uptake data obtained during the last five minutes of each test are used to measure the energy expenditure. The data collected is being analyzed in graphical form.

The risk of impending heat stress increases not only with the ambient temperature, but also with a work load. Results of this study will be useful in determining the workers' average energy expenditure when they perform a given task, and thus to assist with decision-making whether an appropriate micro cooling system is required.

Category: Surveillance

National Estimates of Occupational Injury from the National Health Interview Survey—Geidenberger CA, Jackson LL

The 1988 National Health Interview Survey Occupational Health Supplement is part of a continuing effort by the National Institute for Occupational Safety and Health to improve surveillance of occupational injury and disease. Data from this survey were used to generate national estimates of work-related injury incidence among civilian workers. Eye injuries were a particular focus of the analysis since, in general, such injuries may easily be prevented in the work place at relatively low cost. The overall incidence of occupational injury was 8.6 episodes per 100 workers or 7.2 injured persons per 100 workers. Incidence of injury episode varied by occupation and industry of employment, with injuries occurring most frequently among operator/fabricator/laborer occupations and those employed in the construction industry. Incidence also varied according to body part injured and nature of the injury, with back injury episodes and fractures/dislocations/sprains, respectively, the most common. Risk of injury declined with age for both sexes and was higher for males in every age category. Eye injuries occurred most frequently among those employed in the construction industry and in production/craft/repair occupations. Risk of eye injury was lower than risk of injury to the extremities or back within every occupation and injury category. In addition, those with eye injuries reported fewer days of missed work than did workers with trunk, extremity, or back injuries. Nevertheless, the estimated number of work-related eye injury episodes during the study period (625,745) was substantial, representing 5.9 percent of the estimated total. These results are generally consistent with findings of other injury surveillance systems, and provide further guidance for future intervention efforts.

Traumatic Occupational Fatalities Due to Falls From Elevations—Cause and Prevention—Braddee R, Pratt S

Purpose. To identify and describe trends in traumatic occupational fatalities due to falls from elevations, review recommended prevention strategies, and describe the approach of the National Institute for Occupational Safety and Health (NIOSH) to traumatic occupational fatality investigation and prevention.

Method. This study uses data from the National Traumatic Occupational Fatalities (NTOF), and Fatality Assessment and Control Evaluation (FACE) databases to describe trends and rates of fatalities of workers due to falls from elevations, over a 12-year period. The FACE program, which utilizes the traditional epidemiologic

agent-host-environment model to accurately describe the pre-event, event, and post-event phases of fatal occupational injuries, is conducted in the areas of falls from elevations, logging, and machinery-related fatalities. Through surveillance and epidemiologic investigations, potential risk factors are identified and injury prevention strategies developed.

Results. During the period 1980 through 1991, approximately 72,500 U.S. civilian workers died from traumatic injuries suffered in the workplace according to data from NTOF. Over this 12-year period, an estimated 6,721 of these deaths occurred due to falls from elevations. Although the trend of falls from elevations declined from .68 per 100,000 workers in 1980 to .38 in 1991, falls from elevations remain the 4th leading cause of death Nationwide. Between October 1982 and present, the NIOSH FACE program has investigated 79 fatal incidents that involved workers who died as a result of falling from an elevation. Recommended injury-prevention strategies include working in compliance with national safety standards, establishing and implementing written safe work procedures, using proper personal protective equipment and providing appropriate worker training.

Conclusion. Approximately 560 workers die each year from falls from elevations in the course of everyday work situations, and falls remain the 4th leading cause of occupational injury fatalities Nationwide. In order to reduce these numbers, surveillance, dissemination of prevention strategies, and additional research need to be continued. The FACE model has been demonstrated as an effective tool for identifying and describing fatal occupational injuries and developing prevention strategies. The FACE data has been used to produce targeted dissemination of prevention strategies, and to provide input into the promulgation of national safety standards.

Worker Deaths by Electrocution - A Summary of NIOSH Surveillance and Investigative Findings—Casini VJ, Kisner S

Purpose. To identify and describe trends in traumatic occupational fatalities due to contact with electrical energy, review recommended prevention strategies, and describe the approach of the National Institute for Occupational Safety and Health (NIOSH) to traumatic occupational fatality investigation and prevention.

Research Hypothesis. Through surveillance and on-site fatality investigations of occupational electrocutions, risk factors can be identified and intervention strategies developed, disseminated, and implemented to reduce fatal occupational injuries.

Research Data. Data from the National Traumatic Occupational Fatalities (NTOF) surveillance system, which is based on death certificates from all 50 States and the District of Columbia meeting the following criteria: age 16 years and older; external injury cause of death; and the certifier noted that the injury occurred at work was used. Data are also included from the Fatality Assessment and Control evaluation (FACE) program gathered during field investigations using the traditional epidemiologic model.

Method. This study uses data from the NTOF surveillance system and the FACE database to describe trends and rates of fatalities of workers during to electrocution over a 12-year period. Through surveillance and epidemiologic investigations, potential risk fac-

tors are identified and injury prevention strategies are developed.

Results. According to NTOF data, a total of 5,338 workers were electrocuted in 5,170 incidents from 1980-1992. An average of 411 workers were electrocuted each year, with an average annual rate of 0.4 workers per 100,000 workers. Although the number of electrocution deaths have decreased by more than 50% from 1980-1992, electrocutions accounted for 5% of all worker deaths in 1994 in the U.S. From November 1982 to December 1994, the NIOSH FACE program investigated 224 electrocution incidents resulting in 244 occupational fatalities. Recommended prevention strategies include compliance with national safety codes, proper use of personal protective equipment, appropriate worker training, and developing and implementing comprehensive written safety programs.

Conclusion. Approximately 411 workers die each year from electrocution-related incidents in the work environment, and electrocutions account for 5% of all occupational fatalities in the U.S. To reduce these numbers, prevention strategies need to be developed and disseminated to targeted audiences. The FACE model has been demonstrated as an effective tool for describing fatal occupational injuries, developing prevention strategies, and disseminating these prevention strategies to targeted audiences.

A Profile of Occupational Eye Injuries from the West Virginia Workers' Compensation Program—Jackson LL, Islam S, Bowlers C

Eye injuries are a preventable occupational injury, yet the U.S. Bureau of Labor Statistics estimates that eye injuries account for about 4% of lost work time accidents. Analysis of workers' compensation data provides an opportunity to determine the nature of eye injury in the workplace and to target intervention efforts to higher risk industries and occupations and eventually to individual employers with high incidence rates.

West Virginia is one of only a few states that has an exclusive state-managed workers' compensation insurance fund and does not allow private third-party compensation insurance coverage, although it does allow some companies to self-insure (less than 1% of all companies). We examined 4422 compensable eye injury claims from the West Virginia Workers' Compensation Program for July 1995 through June 1996. The eye injury claims accounted for about 7.6% of the total number of injury claims (58325) during the one-year period. Eighty-seven percent of the claimants are male. The average age of claimants was 35 years, ranging from 14 to 74 years of age, with 85% of the workers in the age range of 20 to 49 years.

Sixty percent of the injuries were caused by various particulate type materials and 23% were caused by chemicals, gases, fumes, or liquids. The major types of accident events were "rubbed or abraded" (60%), "struck by" (20%), "bodily reaction" (7%), and "contact with radiations, caustics, and toxic substances" (6%). The nature of the injury was mostly foreign bodies in the eye (70%) with a fewer number of cuts, punctures, and abrasions (13%) and chemical and radiation burns (7%). Less than 1% of the total number of injuries were caused by imbedded splinters or chips or punctures.

In 82% of the claims the injury involved only one eye, whereas in 10% of the claims both eyes were injured (8% were not specifi-

cally identified). For those claims in which both eyes were injured, the proportion doubled for accidents caused by chemicals, gases, fumes, and liquids (47%) and tripled for accidents caused by contact with radiations, caustics, and toxic substances (21%). Contact with temperature and pressure extremes increased to 8% in comparison to only 2% for all eye injuries. There was also a dramatic increase in burn injuries from 7% for all eye injuries to 34% of injuries involving both eyes.

In summary, the West Virginia Workers' Compensation data provide an excellent opportunity to profile minor as well as serious eye injuries in the workplace.

An Epidemiologist's Trek through Several Industries Injury/Incident Data—Thomas RJ

Analyses of personal-computer-based records of injury data with company historic demographic and job history data presents a different perspective of case definitions and the populations-at-risk than the traditional 'safety' injury/incident counts to 'full-time equivalent' persons.

Data from several different industries of varying size, in scattered geographic locations, and of different types (a utility, an electrical product manufacturer, and a multi-site chemical producer) illustrate the presence of confounding in both the numerator and denominator of traditionally calculated industry rates.

One client's data on current employees, which includes work and injury data back to 1952, leads to a historic view of employee's injuries. There are three employee populations (besides the classic sub-groups of male/female, recent hires/long term employees, et cetera):

- those employees who have not had a single accident/injury
- those employees who have had one and only one accident/injury, and
- a small population of employees who have had more than one accident/injury.

Helicopter External Load Traumatic Injuries — Epidemiology and Prevention—Manwaring JC, Conway GA, Garrett LD

Helicopter external lift load operations are gaining wide acceptance as an alternative to conventional surface heavy lift and transportation. Such operations, however, are not without their hazards. Helicopter external load operations, such as helicopter logging, can be demanding on helicopters and the pilots who fly them. The potential for machine failure and human error has led to tragic results. Helicopter external load operations have been associated with a large number of helicopter crashes resulting in serious traumatic injuries. There were 230 helicopter external load accidents in the United States investigated by the National Transportation Safety Board (NTSB) from 1980 to 1995. These accidents resulted in 57 fatalities and 74 serious non-fatal injuries. Of the 230 accidents, 44 (19%) resulted in one or more fatalities. There was a mean of 0.25 fatalities per accident, and a mean accident pilot fatality rate of 14% (40 pilot fatalities out of 276 pilots involved in 230 accidents). Of the 230 accident reports, 190 (83%) noted a flight purpose. Of these 190 events, 65 (34%) occurred during heli-logging operations. These 65 events resulted in 26 (46%) of all fatalities, and 30 (41%) of the 74 serious non-fatal injuries.

Construction-related external load accidents accounted for 42 (22%) of the 190 accidents. These accidents resulted in 10 (18%) of the fatalities, and 16 (22%) of the serious non-fatal injuries. The rest of the accidents (83 in number or 44%) involved miscellaneous cargo operations (19%), power line operations (8%), christmas tree operations (6%), seismic operations (6%), fire control operations (3%), and agricultural operations (2%). These 83 accidents (44%) accounted for 21 (37%) of all fatalities, and 28 (38%) of the 74 serious non-fatal injuries. According to the NTSB who assigned "primary probable cause" to all 230 accidents, pilot error accounted for 44% (n=102), mechanical failures accounted for 38% (n=88), and maintenance accounted for 10% (n=23) of the accidents. A vast difference in primary probable cause was noted between heli-logging and non-heli- logging accidents. For heli-logging, the primary probable causes were mechanical failure (63%), pilot error (29%), undetermined (5%), and maintenance (3%). For non- heli-logging operations, the primary probable causes were pilot error (50%), mechanical error (28%), maintenance (13%), and undetermined (8%). The risks associated with these probable causes can be minimized by adherence to existing regulations and manufacturer recommendations, improved training, and more frequent and intensive helicopter maintenance. Recent experience in Alaska has shown that following these recommendations can make helicopter external load operations safer, thereby dramatically reducing the number of crashes and injuries.

Category: Miscellaneous

Characteristics of Success Following A Comprehensive Pain Control and Functional Restoration Program—Chen W

Chronic pain is a complex multidimensional problem and a multidisciplinary approach is a preferred model of management in patients with chronic pain. Functional restoration and activity based programs have documented successes in decreasing the disabling effects of chronic pain. The purpose of this study was to describe program and subject characteristics of a multidisciplinary pain program and to identify significant factors that can predict treatment outcomes of such a program. The database of a pain control and functional restoration program was reviewed. Two hundred and ninety-two subjects returned the six-month follow-up questionnaire. These subjects were assigned to either a successful or not-successful outcome group based on clinical judgment of the following criteria: return-to-work (or active retirement), off third-party-support, off narcotics, reduction in pain, and improvement in function. Characteristics of successful and not-successful outcome

groups at the time they entered the program were analyzed retrospectively. Discriminant function analysis was utilized to identify significant factors that classified the two outcome groups. Initial working status, ethnicity, the schizophrenic scale of MMPI, education, and trunk flexion strength were the best predictors that correctly classified approximately 69% of the subjects into their actual outcome groups. This study may provide insight as to some of the factors that may predict treatment outcome.

Use of Narcotic and Non-narcotic Analgesic Medications in Occupational Injuries: Analyses of Reimbursed Prescriptions in a State Run Workers' Compensation Database—Islam SS

Occupational injuries, such as back and shoulder injuries, muscle sprains, etc., often require treatment with analgesics and muscle relaxants. The pattern of such drug uses has not been well documented in work related injuries. In this study, using the West Virginia Workers' Compensation database, we have evaluated the pattern of reimbursed prescribed medications with an emphasis on narcotic and non-narcotic analgesics by specific body parts injured. In addition, costs associated with analgesics, muscle relaxants and anti-arthritis are also presented. Among those who were injured between July 1, 1995 and June 30, 1996, 5557 claims were reimbursed for prescription drugs at the time of data collection. Of the 200 most prescribed drugs, analgesics were the most commonly used drugs (4,724 prescriptions) followed by muscle relaxants (3,359 prescriptions) and anti-arthritis (3,131 prescriptions). However, anti arthritic medications were the most expensive, accounting for an average of \$50 per prescription compared to \$26 and \$25 per prescription for analgesics and muscle relaxants. Ultram 50 mg tablets were the most prescribed analgesics for all body parts injured except for eye and toe injuries. The most commonly used narcotic analgesics was Propoxy-N (Darvocet), followed by Hydrocodone and Butalbital. Among the non-steroidal anti-inflammatory schedule drugs Cataflam was the most commonly used drug followed by Toradol. Cataflam was also the most expensive schedule drug, costing \$50 per prescription. Reimbursement for the cost of medication per day varied widely. For example, reimbursement for a day's supply of Ultram tablets ranged between 17 cents and \$14.30 with a mean of \$3.70. Such variation could result from the variation of actual units prescribed per day and whether or not generic or non-generic brands were dispensed. Further analyses are carried out to understand injury, occupation and industry specific narcotic and non-narcotic analgesics, anti-arthritis and muscle relaxants prescriptions and pharmacoeconomic aspects of cost variation for such medications.



Session 16: Factors Influencing Injury in Construction

A Designer's Influence on Construction Worker Safety—Gambatese JA, Hinze JW

The safety of workers on construction sites has traditionally been addressed and planned by the constructor at the start of construction. This practice stems from the constructor's control of the project site and responsibility for the construction means and methods. While the influence of the constructor's actions on safety is well documented, the affect that other project team members have on construction worker safety is not as well known. One member of the project team, the designer, has traditionally not been involved in construction worker safety. Designers typically limit their involvement in construction worker safety because they feel that they are not educated and trained to adequately address safety, that no tools exist to assist them in addressing safety, and that they do not have the contractual authority or position to dictate jobsite activities. This practice ignores the effect that designers have on construction safety. Designers can positively influence construction site safety by integrating safety considerations into the design process.

Recent research has examined the designer's role in addressing construction worker safety. This research effort involved the accumulation of suggestions for improving construction worker safety while in the design phase. The suggestions provide best design practices for reducing or eliminating safety hazards during construction. As part of the research effort, a computer program which incorporates the accumulated design suggestions has been developed to assist designers in identifying project-specific safety hazards and to eliminate the hazards through the design process. The program allows the designer to access the design suggestions by focusing on various project components, construction site hazards, or project systems.

The computer program provides a user-friendly design tool that can effectively and efficiently allow designers to apply design suggestions to any size or type of project. The program requires only a small amount of computer memory and storage, and is capable of running on any computer with Windows and minimum hardware requirements. The primary users of the design tool are expected to be design personnel. The program is also valuable for use in academic design and construction curriculums for educating designers about construction worker hazards and safety.

Improving Benefits for Injured Construction Workers: an Alternative System of Workers' Compensation in California—Reuben R, Petersen JS, Neuhauser F, Echeverria C, Levine D

Background and Purpose. A common complaint about the workers compensation (WC) system is the inefficient delivery of benefits to injured workers. Workers often do not have a thorough knowledge of their treatment options, benefits are not provided in a timely manner, and the routine disputes over medical and disability claims are unduly costly and time consuming. These problems are magnified in the construction industry since construction workers comprise only 5% of the U.S. labor force, but account for 30% of all WC expenditures. In some construction occupations, the employers' WC payments can be as high as 29% of payroll. The purpose of our study is to examine the performance of a new, privatized, approach to WC in the construction industry called "carve-out"

programs (COs), and their effects on the above mentioned problems. COs remove construction workers from the preliminary stages of state-run systems and place administration in the hands of unions and employers. The stated purposes of these programs are to improve the delivery of benefits to injured workers and reduce employers' WC premiums, thus enhancing employment and workplace safety. Specifically, we focus on California which passed CO legislation in 1992 and where nine COs currently exist.

How are goals to be accomplished? According to union officials, WC insurance companies that underwrite COs, and construction employers, the key to the success of COs is an alternative dispute resolution (ADR) process and the collective bargaining of a preferred provider network of medical providers. The former is intended to reduce the number of disputes as well as their cost and delays, while the latter is intended to reduce medical costs and improve the quality of medical services. The ADR process usually involves three possible steps: ombudsperson intervention, mediation, and, if necessary, arbitration. Either party unsatisfied with the outcome may appeal to the Workers Compensation Appeals Board (WCAB). In California, the ombudspersons reflect a mix of trade-offs in skills with some having medical backgrounds and others legal. Legal backgrounds may help assure greater protection for the individual rights of injured workers while medical backgrounds facilitate resolutions to disputes over appropriate treatment.

Study Method. We are conducting two major case studies of COs that will include focus groups of injured workers, interviews with insurance companies, union officials, employers and their representatives. We are also administering a survey instrument to all the California COs in regards to their economic, safety, medical, and legal performance to obtain outcomes measurements.

Results to Date. Employers who have participated in COs in California have seen their WC premiums reduced on average by 10-15%. These cuts imply that insurers expect a decline in claims and/or cost per claim. Indeed, all but one claim, out of approximately 1000, has not been resolved at the ombudsperson stage. This compares favorably to the state run system where 12% of all filed claims involve an application to the WCAB, and 2% actually go to trial. If these preliminary results are sustainable, and are not coming at the expense of denying injured workers benefits, this privatized WC process may be achieving its stated goals.

Targeting Health and Safety Interventions and Enforcement in Construction: "Trying to Hit a Moving Target That Keeps Changing Shape"—McVittie D

Analysis of Workers' Compensation Board data on all construction employers recording one or more injuries during a 6 year period in 3 selected regions of Ontario, Canada shows that the industry is extremely dynamic and the injury performance of contractors is highly variable.

Sample results of data review for Hamilton-Wentworth Region (a major population centre located 40 miles west of Toronto) showed the following:

Significant Findings:

- A. Number of firms reporting 1 or more injuries: 1139
- B. Number of firms in (A) with active payroll in EACH of the 6 years: 375

C. Number of firms in (A) where the payroll went to "0" in or by 1995 (deemed equivalent to going out of business): 587

D. Number of firms in (A) where the payroll went from "0" to some payroll in 1995 (deemed equivalent to starting up the company during this period): 81

E. Number of firms in (A) where the payroll values went to/from "0", but were still active in 1995 (deemed open/closed-variable): 76

F. Number of firms in (A) where the company reported one or more injuries but NEVER reported any payroll during this period: 20

G. Number of companies in (B) where the firm generally (4 years out of 6) showed a frequency of less than 20 LTI's/million hours: 291

H. Number of companies in (B) where the firm generally (4 years out of 6) showed a frequency of between 20 and 50 LTI's/million hours: 4

I. Number of companies in (B) where the firm generally (4 years out of 6) showed a frequency greater than 50: 23

J. Number of companies in (B) where there was no consistent performance (no 4 years match of any criteria): 57

Within the 23 firms that were consistently "higher than average" (4 years out of 6 they had frequencies greater than 50), there were 196 LTI's during that period and the collective frequency for the group for the 6 years was 114 LTI's/million hours worked, compared to the provincial construction average of less than 30 LTI's/million hours worked.

The Effects of Firm Size on Injury Frequency in Construction—McVittie D, Banikin H, Comm B

Objectives. To assess the influence of firm size on lost-time injury rates

Methods. Reviewed records of Workers' Compensation Board of Ontario data relating injuries, manhours, payroll and firm size.

Results. Data for the period 1988-1993 clearly showed that injury frequency increases consistently as firm size decreases. (follow-on data for 1994+95 show continued trends)

Conclusions. Large firms have a consistently lower frequency of Lost Time Injuries compared to smaller firms. This trend is evident over several years and appears to be unaffected by cyclical employment patterns. Several factors which may be responsible for this effect are discussed.

Significance. These findings suggest that public policy issues relating to occupational health and safety in the construction industry may need to be focussed on small to medium sized firms rather than large firms. New regulations and standards which are designed for larger employers (e.g. standards with requirements which may be predicated by relatively high minimum numbers of workers on particular projects) or which are more readily implemented by large firms may not yield the type of improvement sought, since the injury frequency within that group is already low. New approaches to both enforcement, education and information dissemination targeted to smaller employers are needed.

Sample of data included

Table—Injuries per Million Hours Worked 1988-1993

Size	1988	1989	1990	1991	1992	1993
> 100 workers*	34.03	31.33	27.25	22.17	16.44	11.86
51- 100 workers	35.28	34.55	28.69	24.99	19.34	14.40
26-50 workers	41.47	36.85	33.34	28.40	23.74	17.57
16-25 workers	46.93	40.08	39.16	31.12	25.71	21.88
8-15 workers	46.09	41.41	40.45	34.09	27.62	26.63
4-7 workers	47.27	43.13	40.71	36.71	34.35	29.90
1-3 workers	53.56	48.02	47.03	43.09	40.77	36.07
< 1 worker	68.70	64.20	67.84	70.06	59.32	47.90

*worker = 2,000 hours per year based on WCB calculations from reported payroll

Session 17: Protective Clothing and Equipment

New Design for Industrial Head Protection—McVittie D

CSAO has developed a new design for industrial head protection. The design is the result of several years of field work with construction workers and employers as well as technical design development. CSAO worked with the Canadian Standards Association to improve the requirements for worker protection and assisted with the re-drafting of the standard and the test methods. The new design will be in North American markets by July '97 and it features an enhanced retention system in the suspension as well as improved energy-absorption/dissipation features through the use of deformable fins on the exterior of the shell.

Test data and the development history would be addressed as well.

Physical and Neuropsychological Effects of Heat Exposure on Workers Wearing Protective Clothing—Cameron W, Anger K, Rosenman K

The physiological and neurological effects of heat are critical elements of risk to construction workers. Not only are workers subject to the classic physiological effects of heat but they may also be at an increased risk for traumatic injuries. One hypothesis of this study is that increased heat loading is associated with decrements in judgement, information processing ability, alertness and maintenance of balance. Protective clothing worn by workers in contaminated areas greatly increases the risk posed by heat exposure. The weight of protective clothing and equipment increases the work burden while the clothing's impermeability reduces cooling by evaporation and convection. Even at ambient temperatures of 70° F and below, active workers in protective clothing are at risk from the direct physiological effects of heat. Worker safety may also be jeopardized by heat-related neurological deficits. Reaction time, accuracy, vigilance, and alertness have been shown to decrease with elevated body temperature below those at which physiological effects first appear. Productivity may also be significantly reduced. Guidelines for the control of heat related injuries among workers dressed in standard work clothing have been published by the ACGIH and NIOSH has published suggested physiological monitoring criteria for workers wearing protective clothing. These recommendations have been developed from studies of young, healthy individuals and need further validation by field tests in actual working conditions.

The Carpenters' Health and Safety Fund, in cooperation with Michigan State University and Oregon Health Sciences University, is currently conducting a field evaluation of heat stress among workers wearing protective clothing. Members of the study site workforce who volunteer to participate in the study receive a baseline fitness test and performance evaluation prior to field measurements. A battery of neuropsychological and neurobehavioral tests are administered to each participant until a steady performance baseline is obtained. Each trained participant's physiological and performance status is then measured under actual working condition for several days with naturally varying conditions of heat loading in a desert environment where temperatures can exceed 100°F. Neuropsychological testing, body weight, urine osmolarity, postural sway, and perceived physical status are measured at the start of the day, at mid-shift and at the end of the work day. Data logging monitoring units measure each participant's skin and ear canal temperature, heart rate, leg and arm motion, and blood pressure throughout the day. Work activity is observed and metabolic work levels are established throughout the day. Ambient temperature, protective clothing use, work rate, and individual physical characteristics are used as independent variables which are compared to physiological and neurological responses under stressed and unstressed conditions.

Evaluation of the Effects of Alternative Safety Helmet Designs in a Hot Environment—Davis GA

Forest workers are likely to remove head protection in hot and humid conditions because of thermal discomfort. However, a recent Occupational Safety and Health Administration (OSHA) regulation revision requires all workers in logging operations to wear safety helmets, thus creating a compliance problem. To determine which factors contribute to forest workers' thermal discomfort, this study evaluated subjects' physiological and psychophysical responses during tasks approximating the workload of forest workers in a hot environment. Environmental conditions in the helmet dome space were also evaluated. Three helmets were used in the study: a standard helmet, a passively ventilated helmet, and an actively ventilated helmet. Results showed that wearing any protective helmet did not burden the body significantly for the physiological variables that were tested. Evaluation of the dome space environmental conditions showed that both the dry-bulb temperature (DBT) and wet-bulb temperature (WBT) varied significantly between helmets tested. Psychophysical results showed that ventilation can affect helmet comfort and that weight and fit are important factors in helmet design.

Evaluation of the Relative Strength and Shatter Resistance of Lenses Currently Used for Street and Industrial Eyewear—Vinger PF

This study evaluates the relative strength and shatter resistance of lenses currently used for street and industrial eyewear by measuring the speed and energy required to fracture the lenses.

Seven lenses (high-index plastic, 1 mm and 1.3 mm center thickness (CT); allyl resin plastic, 1.9 mm CT; heat tempered glass, 1.8 mm CT; chemically tempered glass, 2.2 mm CT; and polycarbonate, 1 mm CT and 1.5 mm CT) that met the U.S. ANSI Z80 standards for streetwear glasses and four lenses (allyl resin plastic, 3.0 mm CT; heat tempered glass, 3.0 mm CT; chemically tempered glass, 3.0 mm CT; and polycarbonate, 3.0 mm CT) that met ANSI Z87 standards for industrial safety lenses were tested for impact

resistance to five projectiles (airgun pellets, golf balls, tennis balls, lacrosse balls, and baseballs).

Based on 348 lens impacts, dress and industrial lenses made from glass, allyl resin plastic, and high-index plastic all shattered at impact energies less than those expected to be encountered from the test projectiles during their routine use.

Under the test conditions of this study, polycarbonate lenses demonstrated greater impact resistance than other commonly used spectacle lenses that conform to prevailing eyewear standards. These findings suggest that current ANSI Z87 standards should be re-evaluated.

Session 18: Workload, Stress and Risks for Injury in Hazardous Work Environments—Cross-cutting Research and Interventions

A Program of Simulation Exercises that Teach and Assess Safety Decision-Making Skills to Workers: Lessons Learned and Generalizations—Cole HP

From 1984 until 1990 a program of 70 simulation exercises was developed to teach and assess coal miners critical skills needed to prevent and/or to cope effectively with mine emergency situations. The simulations capture the problems and predicaments faced by miners involved in actual emergency events like mine fires, explosions, and individual and multiple injury events to workers resulting from mine machinery and mining activities. Each simulation exercise is based on actual injury, fatality, and disaster investigations and detailed injury surveillance data that is routinely collected across the industry. The simulation exercises were field tested with approximately 4,000 miners in eight states and found to be valid and reliable devices for teaching and assessing critical skills. To date more than 410,000 copies of the simulations have been used in the United States and additional copies have been used in South Africa, Australia, and China. Miners, their managers, and their health and safety training instructors evaluate the simulations as being authentic, helpful in teaching critical thinking and problem solving, as challenging and interesting, and all want additional simulation exercises for use in future health and safety training.

From 1985 to 1988 a series of 10 similar simulation exercises was designed for fire fighters and hazardous waste workers. These simulations also worked very well. In 1996 two similar simulation exercises were designed and field tested, one with farmers, and one for physicians to help them better diagnose and treat green tobacco sickness, a farming occupational illness. Again, field tests revealed that both simulations were effective.

The Kayle's Difficult Decisions simulation exercise presents the plight of a farm family who want to expand their production by purchasing a second farm, and consequently who face a series of difficult decisions involving finances, increased labor demands, and the need to upgrade equipment for both safety and production. Like the mining simulations, the key predicaments and decision points in the Kayle's exercise are based in studies of economics and injury events in farming as well as on the actual decisions of farmers in similar situations. Also like the mining simulations, the Kayle's exercise is engaging to farmers, rated very highly by them, and helps them to address issues and relationships about the long-term and great cost effectiveness of safety behaviors, a point often

overlooked in the short-term day to day emphasis upon production.

Currently simulation exercises similar to those developed for mining and agriculture are being developed as injury reduction interventions for use with small companies in the construction industry. A recent study of the impact of the mining simulations upon that industry has identified (a) factors critical to the success of that program, (b) lessons learned from this 7-year multiagency effort, and (c) what is and is not generalizable from the mining simulation exercise effort to agriculture, construction, and other occupations. These findings have the potential to influence and improve similar training interventions in these and other industries and trades.

An Interactive Whole-Farm Planning Tool to Evaluate the Relationship between Farm Financial Position and Stress and Injury Risk—Isaacs S

The relationship between farm planning and farm financial position and farm family stress and injury risk is demonstrated through the use of a computer spreadsheet based farm planning tool. This tool allows farmers, educators, and analysts to evaluate the impact of alternative farm plans on net farm income, net cash flow, and seasonal labor distribution.

The farm planning tool allows users to select up to seven crop enterprises and five livestock enterprises. The user also specifies the number of acres for each crop or the number of head for each livestock enterprise. Income and expense estimates for each enterprise are provided from the users' own records or from university enterprise budget estimates. Similarly, seasonal labor requirements and availability are furnished by the user or from university data sources. Fixed costs such as taxes, insurance, depreciation, and utilities can be allocated to specific enterprises or included as a whole-farm expense.

The farm planning tool will calculate net farm income by summing income and expenses across all enterprises and deducting operating expenses from total farm income. The spreadsheet will also evaluate adjustments for family living expenses, off-farm income, depreciation, and loan principle payments to give a net cash flow for the specified farm plan. Seasonal labor availability and labor requirements are shown graphically to illustrate labor surpluses or deficits by season.

This planning tool allows users to quickly and easily evaluate and compare the relative profitability, liquidity, and labor demands of alternative farm plans. The ramifications of workload decisions that result in fatigue and decreased safety performance can be experienced vicariously. Direct and indirect costs related to injuries and injury prevention can be compared, and the impact of injury on farm solvency can be explored. A tool of this type allows farm families to see the economic consequences of alternative plans before putting them into action. Thus stresses associated with low net income, negative cash flow, or labor deficiencies can be anticipated and prevented.

Loss Education Through the Use of Simulations: An Example from the Construction Industry—Kidd P, Struttman T, Mays J, Parshall M

Loss education is the use of teaching methods to convey the concept that, "Safety is an investment, not an expense". The hypoth-

esis tested in this study is that by educating workers, owners, and operators about the losses associated with work-related injury and illness, promoting safe work practices will be viewed as making a positive contribution to the fiscal health of the company and its workers.

Interactive simulations, as training materials, can translate key information into powerful and memorable mental images that are more likely to change behavior than are didactic presentations of the same material. Simulations can provide insights to workers about the economic stressors they face, the associated risk of injury, and the long-term economic consequences of both stressors and injuries. Interactive training materials use step-by-step procedures to elicit workers' opinions and thoughts as the exercise progresses. This form of training maintains the connection between the topic(s) of the training and each worker's experiences on the job.

This presentation will focus on common themes present in six simulations designed to prevent falls - and back injuries. These themes will be contrasted with those discovered through earlier research in agriculture. In both industries, periods of high workload can lead to increased stress and fatigue, inattention to regular maintenance of safety equipment, short-cuts that may compromise safe work practices, and increased risks for injury. This presentation will show how a "loss education" perspective considers the maintenance of safety equipment and the improvement of safe work practices as a necessary part of maintaining productivity and long term economic viability of the company.

The work crew performance model: A method for evaluating training and performance in the mining industry—Wiehagen WJ, Lineberry GT, Lacefield WE, Brnich MJ, Rethl LL

The Work Crew Performance Model (WCPM) seeks to define performance variability within similar tasks of an underground work crew and relate observed variability to a cost consequence. Performance variability is described using worksite observations to determine the adherence to job elements contained within a standard operating procedure (SOP). The importance of the model is embedded within the notion that, oftentimes, the lack of adherence to written job procedures is cited or implied as a contributing factor to lost time injuries.

Key components of the WCPM include: 1) job definition through task analyses and the ranking of job elements by perceived cost consequence; 2) observational techniques for establishing performance baselines by measuring adherence to safe and proficient job procedures; and 3) cost linkages between adherence to task procedures and measures of consequence for noncompliance.

Empirical data was obtained through the study of shuttle car operation in an underground mine in Appalachia. It was found that observed adherence to safe and proficient job procedures by shuttle car operators matched well with the consensus profiles (measured through a nominal group technique) with mining personnel. It was also found that experienced operators consistently outperformed less experienced, incidental operators in each of six major task groups.

These findings imply potential use of the WCPM as a practical procedure for thinking systematically about choices available to

reduce performance variability. These choices include reducing workplace hazards, work organization, and training. Field application of the model might offer useful data to evaluate training and financially support performance improvement strategies that can be tested for their ability to reduce human error, thereby encouraging greater adherence to critical job elements.

Session 19: National Surveillance Systems

Trends in Occupational Fatal Injury Rates in the United States (1983-1992)—Bailer AJ, Stayner LT, Reed LD, Stout NA, Gilbert SJ

Data from the U.S. National Traumatic Occupational Fatality (NTOF) database were combined with data on employment from the U.S. Bureau of Labor Statistics (BLS). The combined NTOF-BLS data were used in a Poisson regression in which the rates of occupational fatality were modeled as functions of year (1983-1992), race (black, white, other), gender, age, industry and occupation.

A decline in race-gender-age adjusted fatal injury rates is observed across a majority of industries (9 of 10 industries) and occupations (9 of 11 occupations). Annual changes over 10 industries ranged from a significant decline of 5.3% per year in "public administration" to significant increases in "wholesale trade." Annual changes over 11 different occupations ranged from a significant decline of 6.2% per year in "technological and related support" to a significant increase of 1.6% per year in "machine operators, assemblers, and inspectors." In general, race-gender-age adjustments resulted in estimated changes that were smaller and beyond demographic characteristics of the worker population. While this finding is encouraging, the increase of fatal injury rates in particular industries and occupations suggests that efforts to improve workplace safety should continue.

Occupational Deaths Associated with Traffic-Related Motor Vehicle Crashes: 1990-1992—Kisner S, Jenkins EL

Occupational injury surveillance systems consistently indicate that motor vehicle crashes are the leading cause of work-related death. Data from the National Traumatic Occupational Fatalities (NTOF) surveillance system indicate that traffic-related motor vehicle incidents accounted for 13,017, or 20% of all work-related fatalities from 1980 through 1989. To better describe these occupational fatalities, data from NTOF were matched with data from the Fatal Accident Reporting System (FARS) for the years 1990 through 1992. This study identifies the industries and occupations with the highest numbers and rates of worker deaths associated with traffic-related motor vehicle incidents, summarizes the characteristics of the events, vehicles, and persons involved in these incidents, and identifies areas for future research and prevention efforts. NTOF is a death certificate-based surveillance system that includes occupational injury deaths to workers aged 16 years and older and FARS is a census of fatal traffic crashes with data abstracted from multiple sources, including police records and coroner/medical examiner reports. Because the FARS data includes detailed information for traffic-related incidents not included on death certificates, the NTOF data were matched with the FARS data to better describe these fatalities. There were 2,474 events that involved at least one

work-related fatality. These events involved 2,135 motor vehicles that were occupied by at least one fatally injured worker and 337 motor vehicles that fatally struck 351 pedestrians who were working. These events resulted in 2,562 work-related fatalities. Seventy-one percent of the events occurred on three roadway types: 27% on a state highway, 24% on an interstate, and 20% on a US highway. Thirty-five percent of the vehicles occupied by at least one fatally injured worker were tractor trailers, 16% were pickups, and 14% were 2- or 4- door sedans. The majority (76%) of those killed were drivers, 14% were pedestrians, and 9% were passengers. Thirty-two percent of the drivers worked in the trucking service, 9% in construction, 5% in crop production, and 4% in justice/public order/safety. Twenty-six percent of the events that involved pedestrians occurred in a construction/ maintenance zone. Thirty-two percent of the pedestrians worked in construction, 10% in trucking service, 7% in automobile repair, and 7% in justice/public order/safety. Of the 1,468 drivers for which blood alcohol concentrations (BACs) were provided, 87% had no indication of alcohol, 5% had BACs between .01 and .09 grams per deciliter, while 8% had BACs of .10—the legal limit of intoxication in most states. Prevention efforts must be emphasized to reduce the number and rate of occupational fatalities involving motor vehicles. These efforts need to address risks common across all industries as well as those specific to particular tasks, such as flagging in construction. Prevention efforts should include education, enforcement, and engineering controls. Additionally, research efforts must continue to address the many remaining questions regarding risk factors and the most effective strategies for reducing occupational motor vehicle-related deaths.

Sentinel Physician Visits and Their Contribution to the Canadian Agricultural Injury Surveillance Program (CAISP)—Alberg NM

In 1996, a collaborative organization representing agricultural groups, government agencies and academics was established in Canada. With a mandate to develop a sustainable and national surveillance system for injury-related farm fatalities and hospitalizations, CAISP is also tracking the progress of out-patient surveillance projects in three provinces.

In Manitoba, sentinel physician offices are used to track out-patient visits for agricultural injuries and illnesses. These out-patient data complement provincial hospitalization and fatality statistics which have been monitored since 1983. The additional data fill important gaps, including the identification of patterns unique to illnesses and non-trauma injuries. All three levels of data, out-patient to fatality, demonstrate the unique "workplace" risks of the youth and elderly members of the farm population.

Extrapolation of this regional surveillance to the provincial scene estimates that for each hospitalization recorded, there are another 20-25 cases seen in out-patient settings.

Analysis of out-patient data in Manitoba, coupled with fatality and hospitalization data from the CAISP program, can provide comprehensive surveillance of agricultural injury events on a population basis. We consider this a vital step in the development of injury prevention programs in our province. This presentation will outline the methodology used in the development of these surveillance systems, and highlight examples that have assisted us in our prevention efforts.

Fires and Explosions Resulting in Fatal Work Injuries—Windau J

Each year, 200 workers are killed by fires and explosions. While other major causes of fatal work injury declined in number from 1994, deaths due to fires and explosions increased slightly during 1995. These incidents often result in multiple worker fatalities. This study will use data from the Census of Fatal Occupational Injuries to profile fires and explosions responsible for worker deaths. Discussion will include the types of substance or equipment involved; the industries and occupations affected by the various types of fires and explosions; and the worker's activity at the time of the incident. The Bureau of Labor Statistics fatality census uses multiple data sources to identify, verify, and profile fatal work injuries. Information about each workplace fatality, such as occupation and other worker characteristics and circumstances of the event, is obtained by cross-referencing source documents, including death certificates, workers' compensation records, and investigation and other reports from Federal and State agencies. This method assures counts are as complete and accurate as possible.

Session 20: Surveillance of Adolescent Injuries***Work-Related Injuries to Massachusetts Adolescents: Findings from the Massachusetts SENSOR Program***—Davis L, Frank E

Work-related injuries to adolescents are significant public health concern. During the last five years, the Massachusetts Department of Public Health has been working to build a comprehensive surveillance system to document and ultimately prevent work related injuries to children in the state. In 1992 the Department passed regulations requiring physician and hospital reporting of occupational injuries to persons less than 18 years old. Physician and hospital reports together with workers' compensation claim data (the "primary" data sources) are used to identify cases. Follow-up interviews are conducted with a subset of cases to systematically collect information about the incident and a range of other factors, including period of disability, health and safety training, and supervision. Select cases are referred to other government agencies for worksite follow-up. These include the Occupational Health and Safety Administration and state and federal agencies responsible for enforcement of child labor laws.

From March 1993 through March 1997, over 2,000 cases were ascertained and 298 follow-up interviews were completed. In this presentation, primary source data will be used to describe the distribution of cases by basic demographic and employment characteristics (age, gender, industry, and occupation sectors) geographic region and nature of injury. Injury rates based on employment data from the 1990 Census will also be presented. Findings will be compared with data on occupational injuries to teens in Massachusetts reported by the Bureau of Labor Statistics Annual Survey of Occupational Illness and Injuries. Follow-up interview data will be used to more fully characterize tasks/processes and equipment associated with work-related injuries to children as well as the extent of health and safety training, lost work/school time and supervision. The Massachusetts Department of Public Health's experience collecting occupational injury data from hospitals and physicians will be discussed as well as uses of the data for targeting innovative intervention efforts.

Adolescent Occupational Injuries: Texas, 1990-1996—Cooper SP, Burau KD, Robison BS, Fraser JJ, Schnitzer P, Richardson S

Our understanding of adolescent occupational injury in Texas is currently at an early stage. Injury data related to adolescents in the workplace are scant and fragmented in Texas, as they are in most states. Investigators used three data sources to describe injuries to working minors in Texas: (1) injuries and illnesses among working youth 14-17 years of age reported to the Texas Workers' Compensation Commission (TWCC) from 1991 through part of April 1996; (2) 1993 TWCC/Bureau of Labor Statistics (BLS) Annual Survey of Occupational Injuries and Illnesses for youth 15-17 years of age; and (3) work-related fatalities identified from Texas death certificates from 1990-1995 for adolescents 11-17 years of age. Most of the cases involve injuries rather than illnesses and are referred to as injuries below. There were 9,027 injuries reported to the TWCC for adolescents 14-17 years of age during slightly more than five years. Most of the injuries were among older teens 16 and 17 years old (93%); yet the 671 injuries to younger working children 14-15 years of age should not be discounted. Sixty-five percent of the injuries occurred among males. Injuries for which indemnity payments were made (i.e., more than 7 days out of work), as an indicator of more severe injuries, occurred among 1,958 adolescents (21.7% of the total group). Injuries resulting in permanent impairment represented 3.4% of the injuries (range of permanent impairment=1 to 100%, median=5%). Eighty-seven percent of these received Temporary Income Benefits for two or more weeks.

Industry, occupation, and detail about injury codes were missing for a large number of these young claimants, making interpretation of the industry/occupation and type/cause of injury results unfeasible. Therefore, a second data source, the 1993 TWCC/BLS Annual Survey, was accessed to better describe injuries by industry/occupation, nature, and cause. In 1993, of 992 non-fatal injuries involving days away from work, 347 (35%) were caused by contact with objects (mainly struck by object), 267 (27%) by bodily reaction (mainly overexertion in lifting), and 24% by falls.

Two-thirds of the injuries occurred while working in eating and drinking places and grocery stores. Forty percent of the injuries occurred in food preparation occupations (primarily due to being struck by an object, falls, or overexertion in lifting), and 18% occurred in stock handlers or baggers (mainly due to over-exertion or being struck by an object). Half of the injuries were sprains/strains/tears or cuts/lacerations occurring primarily to the back, fingers, and hands.

A total of 30 deaths due to unintentional injury and homicide were identified from death certificates for 1990-1995 with the injury-at-work box checked "yes". The majority of the deaths involved males (73%) and older adolescents 16-17 years old (80%). Approximately three-quarters of the deaths were accounted for equally by motor vehicle (37%) and homicide (37%). All 11 homicides involved firearms.

In conclusion, we have documented a substantial number of adolescents who are injured or killed in the workplace each year in Texas. Although improved population-based surveillance is needed, prevention efforts, based on existing knowledge, should be supported.

The Downside of Teen Employment: Hazards and Injuries Among Working Teens in North Carolina—Eversen CT, Schulman MD, Runyan CW, Zakocs RZ, Dunn KA

Objective. Understanding how work experience impacts the present and future well-being of working teens is a central issue for social scientists. Claims as to whether work is a positive or negative experience for teens are based on research about behavioral (e.g., drug and alcohol use, delinquency), occupational (e.g., adult income, occupational aspirations and achievement), and social psychological outcomes (e.g., alienation, cynicism, overall life satisfaction). However, the debate about the consequences of youth work tends to neglect the public health research on the occupational hazard exposures and injuries of working adolescents. We argue that the debate about the consequences of work for adolescent well-being needs to include analyses of the occupational health exposures and injury experiences of working teens.

Methods. In 1995, we conducted a state-wide telephone survey (N=572) of teens age 14-17 years, and in 1996, we re-interviewed a sub-set of the same teens who currently worked restaurants or food service, grocery stores, and retail establishments. Teens were asked questions about the general tasks they performed at work, their exposure to a variety of hazards (both equipment-based and task-based), their safety concerns, any training they received on the job, and types of injuries they suffered.

Results. Analyses show that teens worked an average of five months at their present job for an average of four days per week. Although most teens (94%) reported that they wanted more safety training at work, only half (54%) reported ever receiving training on how to avoid injury. We found significant gender and industry differences in general work characteristics, exposure to several classes of hazards, and the number of types of injuries. Consistent with previous research on the gendered division of labor, we find that males in all three industries tended to work with “things” (e.g., ovens, dishwashers, fryers, produce, grocery carts) while females worked with people (e.g., as cashiers, hostesses, sales people). Teens working in restaurants reported significantly greater exposure to hazards and significantly more types of injuries than their counterparts who worked in grocery or retail stores.

Conclusions. We conclude by emphasizing the importance of placing occupational hazards and injuries within the context of the gendered division of labor, the labor process of the industries in which teens work, and the general debate about the impact of work on adolescent well-being.

The Prevalence and Patterns of Occupational Injury in South Texas High School Students—Weller NF

Introduction/Objectives. Work is a common feature of adolescent life in the United States today. Increasingly, full-time high school students are working longer hours during the school year placing them at risk for occupational injury, already documented as a substantial public health problem. Few studies, however, have examined the relationship between work injury and weekly work intensity in employed students. Further, no known studies have described occupational injuries in students from rural locations in the Southwest, where Hispanic and economically-disadvantaged students, who might be expected to work long hours, are heavily represented. This paper describes the prevalence and patterns of occupational injury in South Texas high school students. We explored

several hypotheses: 1) working students would incur injuries; 2) weekly work hours would be positively associated with incidents of injury; 3) the probability of injury would be greater for males, seniors, racial/ethnic minorities, and students whose parents had poorer educational backgrounds than for females, sophomores, whites, and students having parents with more extensive educations; 4) specific types of jobs would be associated more frequently with work injury; and 5) specific types of injuries would occur more frequently in employed students.

Methods. Anonymous surveys were conducted in 10th and 12th grade student's regular classrooms in May of 1995 (n=3,441). Students representing 23 schools in 29 school districts in 14 counties reported typical weekly work hours, prevalence of injury, type of injury, and type of job when the injury occurred.

Results. Twenty-eight percent of employed students reported ever sustaining an injury while working (n = 505). A dose response effect was observed where increasing hours of weekly work were significantly related to injury (1-10 hours, the referent, Odds Ratio [OR] = 1.0; 11-20 hours, OR = 1.6, [CI = 1.0, 2.0]; 21 + hours, OR = 1.9, [CI = 1.3, 2.5]). The likelihood of injury for seniors and males (OR = 1.0 for both) was greater than for sophomores (OR = 0.8, CI = 0.7, 0.9) and females (OR = 0.5, CI = 0.4, 0.6). Hispanics (OR = 0.7, CI = 0.5, 0.9) were less likely to be injured at work than the referent, other races/ethnicities combined (OR = 1.0); whites (OR = 0.9, CI = 0.7, 1.3) were not different from the referent. No differences in injury probability were noted by parent education or by race/ethnicity and parent education. The univariate odds ratios for injury for restaurant (4.5), agricultural (4.3), and construction work (4.3) were greater than for factory (3.4), yard (2.5), and retail work (2.1) compared to babysitting, the referent (1.0). Punctures/cuts (27% of all injuries) followed by shocks/burns (22%) were among the most common injuries in working teens; these injuries most frequently occurred during restaurant work in both cases (33% of punctures/cuts and 65% of shocks/burns occurred during restaurant work).

Conclusions. Among working students, employment for more than 20 hours weekly during school increased the likelihood of injury. Parents, educators, health professionals and policymakers should continue to supervise the number of weekly hours that students work during the academic year.

Session 21: Occupational Injuries in Health Care

The Growing Epidemic of Traumatic Injuries In the Healthcare Sector—Borwegen B

The healthcare sector is fast becoming the nation's most dangerous industry. The healthcare sector employs over 9 million healthcare workers, having grown by 3 million workers between 1980 and 1992. 700,000 healthcare workers suffer an injury or illness each year, a doubling of the number of injuries and illnesses in the past decade. The healthcare sector now reports more injuries and illnesses than any other sector of the economy. The rate of injury has increased from around 6 per 100 workers per year to 10 workers per 100 per year over the past decade. The segments of the healthcare sector with the fastest growing employment are also experiencing the highest and fastest growing injury rates. In nursing homes for instance, the rate of injury increased again last year

up to 17.8 per 100 workers per year, a higher rate than that for rate for steel workers or construction workers.

Yet, the healthcare sector remains literally decades behind other sectors of the economy in addressing or even recognizing their own workers' occupational health and safety hazards. Think about it; what other sector of the economy would permit one million puncture injuries to occur each year? I am referring to the continued use of an outdated technology, the use of inherently dangerous unguarded syringes. Yet hundreds of safer products are now on the market which could essentially eliminate these injuries and deaths.

This is but one of the many hazards causing traumatic injuries to healthcare workers. In the area of ergonomic risks, hospitals are the leading and nursing homes are the second leading workplaces involving the number of nonfatal occupational injuries and illnesses involving days away from work from back injuries. Yet, again, like needlestick injuries, we know the solutions. With the introduction of safe staffing levels and mechanical lifting equipment, nursing homes have seen dramatic declines in both injury rates and workers compensation premiums.

Looking at workplace violence BLS statistics show us that 38% of all non-fatal workplace assaults which result in lost workdays occur in the healthcare sector, including 24% in nursing homes and 11% in hospitals. When looking at all non-fatal workplace assaults resulting in lost workdays, nursing aides and orderlies are the leading victims, incurring 27% of all attacks, compared to 7% for police and guards. And in 48% of all nonfatal workplace assaults across all industries, the assailant is a healthcare patient (compared to 8% for a co-worker) BLS 1994 data.

There are a wide variety of reasons why this situation has been allowed to continue including: a misperception of self regulation by the JCAHO, a difficulty by society in accepting the reality that a predominately female population could work in such a hazardous environment, the fact that the focus in healthcare is on curative, not preventative medicine, and that the workplace focus is on the health of the patient, not on the worker. Finally, a low unionization rate has lead to a lack of power by healthcare workers to pressure management to improve these conditions.

Yet the biggest threat faced by healthcare workers has yet to take full effect; the threat posed by changes in work organization. The impact of managed care and healthcare restructuring is only beginning to be measured, and the data is quite alarming. The new factors exacerbating this situation include downsizing, deskilling/collapsing of job titles, caring for more patients of higher acuity levels, and the corporatization and gobbling up of non-profit facilities as management's focus continues to shift from the quality of patient care to maximizing profits.

Environmental Risk Factors for Work-Related Assault Injuries Among Nurses—Lee SS, Gerberish SG, Maldonado G, Waller L, Zaidman B, Kochevar L, Anderson A, McGovern P, Lohman WH, Parker D

Within the realm of violence, work-related violence has recently been recognized as a major problem. While there is an emerging literature pertinent to work-related homicides, there is a serious

deficiency in the knowledge of non-fatal work-related violence and relevant risk factors for both fatal and non-fatal events. The purpose of this effort was to identify the magnitude of the problem and related risk factors within a major occupational population (licensed registered and practical nurses).

The research design employed a retrospective cohort involving the population of all registered (n=3D 52,590) and licensed practical (n=3D 23,204) nurses who worked in the state of Minnesota between January 1, 1995 and June 30, 1996. A nested case-control design was used to examine the relation between potential risk factors and work-related assault injury events; exposures including environmental design, protective strategies, administrative policies, characteristics of potential assailants in the workplace, as well as personal characteristics of the victims, were examined. Cases were those persons who filed a workers' compensation claim, associated with work-related assault injury during the study period. Controls were selected, according to practice type (registered nurses or licensed practical nurses), from the population at risk during the study period, using a random sampling method.

Based on knowledge from previous published research efforts and knowledge of injury mechanisms, a conceptual model for risk factors for work-related assault injuries among nurses was developed. According to this conceptual model, data collection instruments were developed to obtain exposure information from both cases and controls. Cases were questioned about their exposures prior to and during the incident. Controls were questioned about their exposures on a randomly selected time from the study period to provide the person-time exposure information.

The conceptual model was also used to identify potential confounders for specific risk factors. Multivariate analyses, using logistic regression, enabled modelling of the dependence of assault injuries on the exposures of interest and confounders.

Initial univariate logistic regression analysis (including 63 cases and 415 controls) identified the following variables as potentially important risk factors: environmental exposures including the type of the facility, ownership of the facility, type of department/unit, type of shift, proportion of hours worked in direct patient contact, and the number of patients assigned; patient characteristics including: mental status and length of stay in the facility; and personal characteristics of victims including: training, previous assault history, and ever having witnessed assault in workplace. Several environmental security measures were identified as potential protective factors. Through initial multivariate analyses, the following were identified as important risk factors: patient mental status; patient length of stay in the facility; working alone; and prior training. The presence of video monitors and security personnel were identified as important protective factors. Rate ratios ranged between 2.2 and 18.5 for risk factors and between 0.2 and 0.35 for protective factors, with respective confidence intervals excluding one.

This is the first such comprehensive effort, including a major analytic component, to investigate the problem of assaults among nurses. Through this endeavor, specific risk factors for this important problem have been identified. This information serves as a basis for the development of appropriate prevention and control strategies.

Selection and Installation of Sharps Disposal Containers in Healthcare Settings—Kasting C, Mullan R, Martin L

Aim. To provide criteria for selection of the appropriate sharps container, based on a site specific hazard analysis and to provide recommendations for the installation height for the sharps disposal containers (SDC).

Methods. Criteria for the design, selection, and appropriate use of SDCs have been developed. These criteria include: design performance criteria, placement, use, disposal, and “model” selection criteria. Maximum and minimum height dimensions for two design situations (standing or sitting) were calculated based on anthropomorphic tables to accommodate 95% of all adult female workers.

Results. The basic formula is: fixture height = (level eye height) - (tangent 15°)(maximum thumb tip reach, MTTR). The middle 50% distance of the MTTR was used to adjust for elbow and wrist bending and other human behavior variations. If level eye height is assumed to be 57 inches and the modified MTTR is used, the range of optimal installation heights for fixed, wall-mounted SDCs is 52 to 56 inches from the floor for a standing workstation and 38 to 42 inches for a seated workstation. Health-care workers should be able to comfortably visualize the SDC, and containers should be located within arm’s reach.

Conclusion. The selection and use of SDCs installed within an acceptable range can facilitate the reduction of sharps-related injuries within the health-care facility.

Work-Related Injuries Among West Virginia Emergency Medical Services Providers—Derk S

Introduction. Emergency Medical Services (EMS) personnel may encounter hazards as they care for patients in a prehospital setting. Concerns such as infectious disease exposure, physical violence against them, and personal injury given circumstances and situations of the scene are present as EMS personnel do their duties.

Purpose. The purpose of this study was to collect data concerning injuries, safety equipment availability and usage, and safety concerns of EMS personnel.

Methods. A convenience sample was obtained at the 1994 West Virginia EMS Conference. The questionnaire was adapted from a survey done by the New Jersey Trauma and EMS Research Center, University Hospital, Newark, NJ. The survey instrument asked EMS personnel regarding injuries sustained, safety equipment availability and usage, and demographic questions.

Results. Of those participants at the conference 133 returned completed surveys. Respondents were from county EMS (45%), hospital-based EMS (12%), fire departments cross-trained (21%), municipal EMS (7%), state EMS (6%), fire department civilian (5%), and other EMS (4%). Of the 133 respondents 48% were paid/volunteers, 35% were volunteers only, and 17% were paid only. Eighty-six percent were trained in both basic life support and advanced life support.

Sixty-five percent of the respondents indicated they had never been injured, the remaining 35% reported sustaining at least one injury while on duty. Activities reported during time of injury include

lifting/carrying/loading/unloading patients (54%), patient care (18%), exiting/entering/inside the ambulance (14%), and other activities (14%). Reported types of injuries sustained included back injuries (38%), sprains/strains (11%), lacerations (9%), broken bones (7%), contusions (4%), and other injuries (7%). Also included were one joint dislocation, one exposure to blood, and one needle stick. Thirteen percent of the respondents indicated two injuries and it is not clear whether or not they were related to the same incident.

Seventy-six percent (34) of those injured felt it could have been prevented. The most common ways reported to prevent the injury were better lifting techniques or training, paying better attention to environment, partner, and patient, and obtaining more assistance.

Respondents who indicated concern for hazards or injuries while on duty were most concerned with exposure to infectious diseases such as HIV, Hepatitis, and TB. Few respondents indicated that physical injury was a concern.

Safety equipment indicated by respondents as either provided or required included gloves (91%), eye protection (88%), helmets (61%), turnout coats (46%), bunker pants (39%), coveralls (34%), and hip boots (26%). When respondents were asked if they felt that the use of protective equipment may have prevented an injury, only 39% percent agreed. However when asked if the use of protective equipment did prevent a potential injury, 57% agreed.

Conclusion. EMS personnel are experiencing injury from lifting/carrying/loading/unloading patients. The areas of injury include strains and sprains of the neck/shoulder, back, and legs/knees. EMS personnel surveyed are concerned about exposure to infectious diseases as well. The use of protective equipment and an increase in physical fitness and training may reduce exposures to infectious diseases and the number of injuries sustained.

Human Factors Techniques to Reduce Injuries in a Hospital Environment—Wolf LD

This presentation will discuss the following three techniques that used human factors methodology to reduce the cost of injuries in a large urban hospital: 1) Training and Intervention by Professional Ergonomists, 2) Implementation of Participatory Teams to Reduce Injuries, and 3) Ergonomics Component in a Wellness Program

Technique #1: Training and Intervention by Professional Ergonomists

Purpose. To evaluate the effectiveness of an educational and workstation redesign intervention on workers compensation costs and productivity in an office setting.

Method. 117 workers employed in a hospital setting received training in ergonomic issues and an evaluation of their workstation. Workstation changes or purchases as recommended followed each evaluation. Subjects received a baseline survey and follow-up surveys at 5 months, 1 and 2 years. Workers’ compensation costs and productivity measures were evaluated.

Technique #2: Implementation of Participatory Teams to Reduce Injuries

Purpose. To reduce injuries among health care workers through the implementation of Employee-Management Advisory Teams (EMATs). This is a team of employees and supervisors that iden-

tify problems and solve them with ergonomics. This is one of the first documented programs to use participatory ergonomics programs to reduce injuries among health care workers.

Method. Three EMAT groups were formed among employees of a large urban hospital. The EMATs represent three different worker groups—orderlies, intensive care nurses, and laboratory technicians. Each group consists of 4-6 members plus technical advisors. Baseline, one year, and two-year follow-up data will be available for this presentation.

Technique #3: Ergonomics Component in a Wellness Program

Purpose. To reduce workers' compensation costs and improve employee comfort.

Method. A team of novice technicians will provide ergonomic services for as many employees in the hospital system as possible in one year. Records of the quantity and type of intervention will be recorded. Workers compensation costs and injury rates will measure success. Four-month data will be available for this presentation.

Results. Discussion of all three techniques will include impact that ergonomic interventions had on workers' compensations costs, injury rates, self reported symptoms, pain and comfort ratings, costs per injury, and productivity.

Conclusion. A comparison of three very different techniques of implementing human factors principles with hospital employees will be evaluated. Technique #1 with professional ergonomists has been proven but can be too costly for some interventions. Technique #2 using participatory teams can work in some settings but does not seem to be successful in areas with direct patient contact. Technique #3 is still under investigation but has promise due to the combination of approaches that will be implemented.

Session 22: Computer Simulation and Modeling

Ergonomics Analysis Using Computer Animation—Sistler F, Waly SM, Husser R

Computer animation was used to perform an ergonomic analysis and re-design of an eight-piece, cut-up saw workstation in a poultry processing plant. The joint angles of the upper extremities and the back were measured for the existing workstation configurations and for the OSHA recommended height. Both situations created undesirable joint angles during some portions of the cut-up operation. The OSHA recommended height was not acceptable because the worker had to bend too far to view the blade as it was cutting the chicken.

A three-camera video digitizing system was used to collect joint angle data to analyze the tested configurations and to validate the accuracy of the animations. Data was collected on three workers, each with several years' experience on a cut-up saw workstation. The shortest, tallest, and an average-size worker were used. Each was measured at the present in-plant configuration (3-4 inches above OSHA recommended height), at the OSHA height, and two inches below the OSHA height. The standard deviation between the joint angles in the animation and the actual worker movements was less than the standard deviation of the joint angles among the chickens cut by the same person with the same saw configuration. There was a natural variation of motion when a person performed the same task multiple times. Since the variation between the anima-

tion and the average, actual performance of the task was less than the natural variation when a skilled human performed the same task several times, the model was considered to be operating at an acceptable level of accuracy.

The elbow and shoulder angles were more extreme at the in-plant saw height than at the OSHA-recommended height. When the workstation was changed to the OSHA height, the back bending became more severe. The worker had to bend over more to see the blade at the OSHA height. Animation software was used to create a three-dimensional model of the workstation including the saw, stand, chain conveyor, bag and bag holder, and the conveyor for holding the filled bags. Three-dimensional human models were acquired and modified to match the measurements of the workers.

A workstation design was needed where the saw's guide bar could be lowered to reduce shoulder and elbow movements, and still allow the worker to see the blade as it cut the chicken. This was accomplished by lowering the saw and rotating the guide bar. Rotation angles of 10, 20, and 30 degrees were evaluated. An angle of 20 degrees was found to produce the most ergonomically desirable configuration. The average rotation angles for the elbows, shoulders, and back were all reduced.

Mining Equipment Safety Analysis Using Computer Modeling Research Tools—Ambrose DH

NIOSH, Pittsburgh Research Center recreates and analyzes mine accidents and incidents involving mining equipment using 3D computer graphics modeling research tools. The objective is to examine, evaluate, and determine changes that need to be made to mining equipment or human interaction with the equipment to provide worker safety. Comprehensive accident or incident reports are used to develop an accurate visual 3D computer graphics representation of accidents/incident, including the equipment, environment and worker. Computer simulations are used to analyze the accident/incident to predict equipment problems that have contributed toward the accident/incident. The human interaction with the equipment is also analyzed using simulation software. Software packages DADS and JACK are used for simulation and analysis. This paper discusses several completed examples of the use of 3D computer graphics modeling research tools, specifically with mine hoist and elevator systems and underground coal mine roof bolter machines.

Occupational Traumatic Injury Prevention Using Virtual Reality—Dotson B, Hsiao H, Chiou SS, DiPasquale JJ

In the area of safety research, it would be useful to measure the physical responses of workers in their work environment. The physical response data could then be used to compose recommendations to achieve safer work environments. In many cases this is not possible due to various problems. One such problem is that the measurement systems may not function properly in a work environment. Another concern, is that using the measurement system may add risk of injury to an already dangerous job. At the National Institute for Occupational Safety and Health (NIOSH), researchers are looking at a solution to this problem, where the subject is placed in a computer generated virtual environment. This solution uses state-of-the-art virtual reality devices to give the subject the illusion of being in a work environment. Using virtual environments alleviates the space constraint problems that physical mockup may have, but most important is the reduction of the risk of injury for the subject. NIOSH researchers are using virtual

reality in a study which investigates the physical responses of scaffold workers while walking on elevated planks. The subjects in this study will be immersed in a virtual environment that will provide the illusion of being elevated thirty feet above the ground, but in reality the subject will be walking safely on the floor in the laboratory. This paper describes the current project using virtual reality and ideas for future projects using virtual reality.

Computer Simulation of ROPS Testing in ASAE S519—Harris JR, Mucino V, Etherton JR, Snyder KA, Means KH

The American Society of Agricultural Engineers (ASAE) is one professional society which has developed a standard for certification testing of rollover protective structures (ROPS) on agricultural tractors. Certification of a ROPS can be performed following static procedures in the current standard, ASAE S519. This research simulates rollovers about the rear axle and compares ROPS stress levels with stress levels found during simulated ASAE S519 static testing.

The ROPS modeled in this simulation is representative of one that might be found on small tractors (~50 hp PTO) operated on a hillside. Modeling has been performed using finite element techniques. Variables describing the ROPS construction, such as part dimensions and materials, have been parameterized to allow rapid simulation of a variety of ROPS prototypes. Additional variables include the ground slope and the tractor's initial rotational velocity. For the current research, slope angles of 10, 30, and 60 degrees were examined. Initial rotational velocities included 1, 3, and 4 rad/sec. A slope angle of 60 degrees matches the slope recommended in ASAE S519 rear field upset tests. An initial rotational velocity of 4 rad/sec, when converted to a pure translation, is in excess of the speed recommended for the ASAE S519 rear field upset test.

Initial analyses began the rear rollover model at 90 degrees to the ground plane since ROPS-ground contact occurs in the final 90 degrees of rollover. Furthermore, this initial position served to conserve computer time and storage space. For these simulations, it was observed that ground-impact induced stress levels recorded during rear rollovers were on average 19.4% lower than stress levels recorded during simulated static ASAE S519 testing. However, these simulations failed to identify slope angle as a major contributor to ROPS stress. The rear rollover model was modified to initiate the rollover at the point of no return, when the tractor center of gravity is vertically above the rear axle. Starting the simulation at this point will model the energy transfer during the overturn, from potential to kinetic, more accurately than the previous simulation. Preliminary examination of these data suggests the new simulation identifies a more pronounced slope angle effect on ROPS stress.

Future work will include development of models for side rollovers based upon knowledge gained in rear rollover simulation work.

Session 23: Agricultural Injuries

The Ohio Agricultural Safety Promotion System (ASPS), 1994-1997—Eicher LC, Bean TL, McCaslin NL, Nieto R, Owens M, Nolan J, Rodriguez J, Wessel P

Many farms in the United States continue to be family-run operations. However, over the last fifty years, there has been an increase

in the number of corporate agricultural operations that rely on non-family labor. Since the farm crisis of the late 1970's and early 1980's, this trend has accelerated with an increasing number of family farms either "down-sizing" to become part-time farming operations or "up-sizing" to become family corporations. There has also been a trend for operations that have remained primarily family-run businesses to become increasingly reliant on non-family labor to remain competitive and to meet production demands. Furthermore, more and more states now require that agricultural employers carry workers' compensation coverage on their employees.

These circumstances afford an ideal opportunity to reduce the agricultural death and injury rate by working with agricultural organizations (The Ohio Farm Bureau, The Ohio Pork Producers Council, and the Ohio Division of the National Organization of Independent Business) who have workers' compensation programs. A random selection of farms was conducted from a population of 1,700 employers. The Ohio State University provided safety information and training materials for employers to provide short, frequent safety training for their employees. Half of these individuals are in the treatment group, half in the control group. A representative sample (90) of employers in both the treatment and control groups were selected for on-farm inspections of worker protection equipment, shielding, etc. A pre- and post-safety awareness test was also developed and administered to both the treatment and control groups. In addition, accident history prior to the one-year testing period was collected to document pre-treatment accident rate. This approach will validate the use of employer training programs in the agricultural industry for improving cognitive, attitudinal, and behavioral characteristics of employers and employees in farming operations.

Livestock-Related Injuries Associated with Cattle Handling in Oklahoma—Huhnke RL, Hubert DJ, Harp SL

A 1993 study by the USDA's National Agricultural Statistics Service showed 26% of the work-related injuries that occurred on U.S. farms were sustained while working and handling livestock. A 1994 NIOSH farm injury study conducted in Oklahoma revealed that greater than 75% of all lost-time injuries were from handling beef, sheep, and swine. An important consideration in this investigation of livestock-related injuries is whether (and if so, how) handling equipment and working facilities contributed to the sustained injuries. The purpose of this study was to assess the hazards associated with animal handling in a cow-calf operation. This research was funded by the Southwest Center for Agricultural Health, Injury Prevention, and Education at the University of Texas Health Center at Tyler.

Over 6000 Oklahoma cow-calf operators were identified through a random sample from the population of more than 60,000 operators. Individuals identified were mailed injury survey cards inquiring whether they or an individual associated with their operation were injured while working cattle during 1996. In addition, producers were asked whether they would be willing to participate in a voluntary personal interview. Based on the information obtained from the initial mailing, researchers identified willing participants and potential candidates for interviews. Selected individuals were then interviewed by either a county agriculture extension agent or one of the researchers. All in-person interviews were completed within about a two-month period ending May 15, 1997.

Information presented will include the frequencies, types and severity of injuries incurred; and to what extent the physical design and/or operation of cattle handling equipment and facilities contributed to the occurrence of injuries.

Women in the Fields: A Comparison of Injuries in Kentucky and Texas—Browning SR, Westneat S, Reed D, Skarke L

Women are a vital labor component on family farms yet little is known about their risk for occupational injuries in the farm environment. Data from studies completed in Kentucky and Texas allow us to perform cross-state comparisons of overall, farm and non-farm injury rates, to examine the circumstances associated with the injury event, and to describe the characteristics of women sustaining these injuries.

Data from both states were collected through NIOSH-sponsored projects: the Farm Family Health and Hazard Surveillance Project in Kentucky and the Texas Panhandle Family Farm Health and Injury Survey in Texas. In Kentucky, a two-stage cluster design was employed, with a random sample of women living on Kentucky farms selected for a 30-minute telephone interview. For the Texas project a systematic random sample of farms from five county plats listings was used followed by a random selection of women on these farms, as in the Kentucky study. Interviews were completed with 992 farm women in Kentucky and 665 farm women in Texas.

A comparison of injury rates for women in Texas and Kentucky found Texas women to have a significantly higher overall injury rate: 13.1 per 100 women compared to 9.0 ($p = .01$). The rates for farm injuries (injured while doing farm work or farm chores), however, were strikingly similar with a rate of 3.0 per 100 women for Texas and 2.4 for Kentucky ($p = .47$). Work involving animals was the leading injury causing activity in both Texas (25% of injuries) and Kentucky (21%). Moving irrigation pipe (10%), lifting (10%), and walking (10%) were other primary injury causing activities in Texas. In Kentucky, tobacco production (21%), work with farm equipment (17%) and walking (17%) were identified as injury causing activities. Contact with foreign objects and body twists/strains while undertaking these activities were the two primary external causes of farm injury among both Kentucky and Texas women.

The rates for non-farm injuries are significantly different between the two states with a Texas rate of 9.9 per 100 women and a Kentucky rate of 6.5 ($p = .01$). Walking was the most often mentioned activity at time of injury for both states (Kentucky: 46.2%, Texas: 35.4%) followed by household cleaning (Kentucky: 27.7%, Texas: 26.2%). As with the farm injuries, contact with foreign objects and body twists/strains were the primary external causes of non-farm injuries among both groups of women.

The results suggest a relatively modest risk of injury resulting from farm chores for women in Texas and Kentucky. The primary external causes of injury are similar in the two states and suggest that several relatively simple interventions (eye protection, back supports, and non-slip footwear) may aid in the reduction of injuries.

Farm Injuries Among Deep South Farmers—McGwin G Jr., Enochs R, Roseman JM

Purpose. Agriculture is one of the most hazardous occupations. There have been few prospective studies of farm injuries and their

determinants, none involving large numbers of African-Americans (AA) farmers and none in the Deep South. We conducted a population-based prospective study of farm-related injuries among farmers in Alabama and Mississippi. The research objectives were to evaluate the determinants of agricultural injury and to compare them among Deep Southern AA and White (W) farmers with the goal to identify ways to reduce farm injuries.

Research Hypothesis. The hypotheses of interest were that there are differences in injury rates and specific differences and similarities of the determinants between W and AA farmers.

Methods & Research Data. Between January 1994 and June 1996, a population-based sample was obtained through state agricultural statistics services databases and local recruitment. A total of 1297 male farmers from nine rural counties with a large AA population were enrolled and completed a questionnaire on demographic and farming characteristics. Subjects were contacted every six months through January 1997; the response rate was 92%. Frequency distributions were used to generate descriptive statistics. Cox proportional hazards models were used to generate risk ratios (RRs) and 95% confidence intervals (CIs).

Nearly half of subjects (46%) were African-American. The mean age was 52. Two-thirds of farmers had a high-school education or less. The average duration farming was 30 years. The majority of farmers worked with either field crops (44%) or livestock (30%). Seventy-nine (79%) percent were classified as owners/operators; the remainder, farm workers.

Results. The crude injury rate was 3 per 100,000 farming-hours (29 per 100 farming-years). AA farmers had a RR of 2.8 (95% confidence interval (CI) 1.8-4.2) when compared to W.

In both races, injuries involving farm machinery were most frequent, followed by livestock and falls.

The following factors were identified as being independently associated with injury occurrence in multivariable Cox models: being AA (RR=1.5, 95% CI 1.0-2.5); being a farm worker (RR=3.3, 95% CI 1.9-5.6); lacking farm safety training (RR=1.6, 95% CI 1.1-2.4); having a previous farm injury (RR=1.6, 1.0-2.4); full-time farming (RR=0.4, 95% CI 0.2-0.6); tractor use (RR=0.6, 95% CI 0.3-1.0); and having farm machinery in excellent or good compared to poor condition (excellent/good condition: RR=1.7, 95% CI 1.4-3.7).

Conclusion. African-American farmers in the Deep South have higher injury rates than their white counterparts. We have identified several factors as being independently associated with injury occurrence, some of which are amenable to modification. These results should serve as the basis for an intervention study within this population.

Session 24: State and Regional Surveillance Studies

Fatal Work Injuries in the Oil and Gas Extraction Industry in Texas, 1991-1995—Richardson S

A study was conducted of traumatic workplace deaths in the oil and gas extraction industry (SIC 13) from 1991 through 1995 in

Texas using data from the Census of Fatal Occupational Injuries (CFOI) program. A total of 165 traumatic work deaths were identified in oil and gas extraction industries in Texas over the five-year period of the study. That number represents about one-third of the national total for the industry over that period. The calculated rate of 19 fatal work injuries per 100,000 oil and gas extraction workers in the state over the period of the study was more than three times the overall state rate for all industries. The high rates for the industry were led by oil and gas field services (SIC 138) which accounted for 135 of the 165 traumatic work deaths and recorded a rate of 37 fatal work injuries per 100,000 workers.

Fatally-injured workers in oil and gas extraction were predominantly male (99 percent) and White (95 percent). Hispanics (who are counted in the total for Whites) were involved in 30 percent of the incidents. The occupations recording the highest number of fatal work injuries over the five-year period were oil well drillers (16 percent) and truck drivers (16 percent). Workers who were struck by objects accounted for one out of every four fatal work injuries over the period of the study. Other fatal events included highway accidents (19 percent), contact with electric current (10 percent), and falls to lower levels (10 percent).

Employment in the state's oil and gas extraction industry accounts for one out of every four mining workers in the nation. With persistently high fatal work injury rates in mining, successful injury prevention efforts in the state's oil and gas extraction industries would have an important impact on the overall mining picture, both in Texas and nationally. More importantly, renewed vigilance in terms of surveillance and intervention efforts could significantly reduce the high number of preventable incidents occurring within this industry.

High Risk of Fatal Injury Among Self-Employed Workers—Loomis DP

Self-employment is becoming more common in industrialized countries, as large companies downsize and contract out work formerly done in-house. However, there is cause for concern because self-employed workers are exempt from most occupational safety and health regulations. We studied fatal occupational injuries among self-employed workers in North Carolina during the period 1978-1991. Cases were identified through a state-wide medical examiner system, and estimates of person-time at risk were obtained from the census of population. Self-employment grew 40% during the study period, versus 33% for total employment. There were 238 deaths from unintentional occupational injuries among self-employed workers (11% of such deaths among all workers). Relative to other classes of workers, self-employed victims tended to be older (mean age 52 vs. 38) and were more often of European ethnicity. At 6.29 per 105 worker-years, the crude rate of fatal injury at work was higher for self-employed workers than among employees of private firms (3.87 per 105) or government workers (1.46 per 105). The excess of fatalities among self-employed workers was concentrated in several of the most hazardous occupations and industries, notably trucking, where the fatality rate was 37.4 per 105 among self-employed drivers vs. 27.0 per 105 for drivers who worked for private companies, and lumber milling, where self-employed workers had a death rate of 45.4 per 105 vs. 19.7 for those working for others. Self-employed workers in taxi services, agriculture, and agricultural services also had higher occupational fatality rates. However, self-employed workers had relatively lower fatality rates in some other hazardous occupations and industries,

including logging, fishing, and construction. Explanations for higher occupational fatality rates among self-employed workers need further investigation. Recent reports suggest that self-employed contractors perform an increasing share of hazardous work for large firms. People who work for themselves are also likely to have limited capital, time, and training for improving safety on the job, in addition to being exempt from government occupational safety standards. This appears compatible with higher risks among self-employed truckers, taxi drivers, and lumber producers, who may use older, less safe equipment. Self-employment may also allow more vulnerable elderly people to extend the time they can work and be exposed to occupational hazards.

Differences in Occupational Injuries by Gender in West Virginia: Analyses of Workers' Compensation Claim Database—Islam S, Hobbs G, Haque A, Greenwood J, Bowers C, Ducatman A

Gender differences in overall injury pattern and the cause of injuries related to workplace have not been well documented. We compared work-related injury claims between men and women using West Virginia Workers' Compensation database. All workers who were injured between July 1, 1995 and June 30, 1996 were included in this analysis. Number of employments reported to the West Virginia Bureau of Employment during 1995 calendar year was used as a denominator for estimating gender specific rates. Information on age, gender, occupation, industry of employment, the county where accidents occurred and method of first report was abstracted from various data files. In addition, information on reported physical effect of accidents (nature of injury), body parts injured, cause of an accident, time intervals between date of accident and date of claim entry, claim status and total amounts paid for lost time at the time of data collection was obtained. Of the 58,325 claims submitted, 98% had information on gender, 70.8% of these were men and 29.2% were females. The average age at the time of injury was 37 years with no significant difference in age by gender. The injury rates for men and women differed significantly with males having greater injury rates (11.4% vs. 5.4%, $P < .001$). However, analysis of the injuries by body parts showed significantly increased reports of back injuries in women compared to men (women 23%, men 18%). Women reported greater percentage of hand (women 8%, men 7%), wrist (women 7%, men 3%) and shoulder (women 5%, men 3.6%) injuries compared to men; while men reported significantly more eye (men 10%, women 3%) injuries. The cause of an accident also differed between men and women. In both men and women, the most common nature of injury was sprains. The proportion of women reporting sprains were significantly higher than men (44.4% Vs. 33.4%) while men reported more foreign bodies in the eye (men 6.9%, women 2%) and bone fractures (men 4%, women 2.8%). For both men and women, the most commonly cited materials and equipment in use when the accident occurred, were "surfaces not otherwise classified" (men 30.1%, women 29.5%). A significantly greater proportion of women compared to men reported animal bites as the cause of an accident (11.5% vs. 2.2%). Analysis of the cost of compensation for lost time showed no significant difference in the cost per claim between women and men (Mean, SD for women \$4151, \$7091; for men \$4240, \$7474). Types of compensation awarded did not differ by gender with majority receiving temporary total disability (women 80.5%, men 80.3%). Additional data are being analyzed and will be presented on specific occupation and industry groups related to the reported injuries and associated compensation cost.

Work-Related Limb Trauma in a Major Teaching Hospital in India—Joshi TK

The objective of the investigation was to study the prevalence of work related limb trauma in Lok Nayak Hospital, New Delhi.

Methods. The centre for occupational and environmental health in Maulana Azad Medical College, under Delhi university is the first academic centre to be set up in India in 1995. The centre investigated the work-related limb trauma cases being managed at the trauma centre under the aegis of orthopaedic department in 1995 soon after it was set up. The investigation included all cases of upper and lower extremity trauma which were hospitalised.

Results. A total of 61 cases of upper and lower limb trauma were identified and included in the investigation. The frequency of work related limb injuries was 27 per cent. Upper extremity trauma constituted bulk of cases (94 per cent). The mean age of the victims was 26 years. Nearly 76 per cent of victims belonged to the age group 21-30 years. There was one case of hand injury aged 12 years, a child labour. The crush injuries of hand and fingers comprised 75 per cent of all upper limb trauma. The industry involved was small and medium sized and included farm workers, machine operators, plumbing, and other factory workers. All cases were treated surgically by a team of trauma specialists with expertise in hand injury management. All victims enjoyed first class care in the hands of some of the best experts, with satisfactory outcome. The trauma specialists regretted that same injuries keep on occurring. However, the rehabilitation of the victims could not materialise due to non Co-operation from employers. Following this pilot study the occupational and environmental health centre in conjunction with hand injury clinic in the hospital is planning a collaborative project for prevention of such preventable injuries. The labour department's Co-operation is being sought to address the problem of child labour and rehabilitating the injured victims.

Conclusion. The pilot study was able to highlight the importance of work as a source of serious preventable limb trauma being managed at the hospital. The prevention will not only lead to the cost saving but also eliminate the needless suffering of employees in concerned industry. The fact that despite government's determined efforts child labour is still prevalent in small and medium sized industry, a more rigorous enforcement of the child labour protection rules is needed.

Session 25: Preventing Injuries to Adolescents

Improving Workplace Safety: Suggestions from Working Teens—Zakocs RC, Runyan CW, Schulman MD, Evensen CT, Dunn KA

Objective. Occupational injuries are a serious threat to working teens. To improve teen workplace safety, interventions need to target both workers and workplaces. Child labor laws restrict youth from working in hazardous occupations, using dangerous equipment, and working long hours. However, little is known about the ways in which teen workers believe the workplace can be made safer. Using both quantitative and qualitative methods, this study examines North Carolina teen workers' perceptions about their work environment, and the ways in which teens believe management could make the workplace safer for them.

Methods. In 1995, we conducted a state-wide telephone survey (N=572) of teens age 14 to 17 years, and in 1996, we re-inter-

viewed a sub-set of the same teens (N=122) who were working in food service, grocery store, and other retail establishments. We also conducted six focus groups with a different sample of 49 working teens in both urban and rural areas.

Results. Findings from both the 1996 survey and focus groups indicate teens perceive some workplace dangers; although this perception was more pronounced in the focus groups. Forty-five percent of the teens surveyed believed most jobs that teens have are unsafe; 23% were concerned about being exposed to workplace hazards; and 40% always or often felt rushed at work. Although most teens (82%) report some type of training, only 54% were ever trained to avoid injury or how to deal with an angry customer; 40% on how to deal with a robbery; and 23% on how to deal with sexual assault. Both data sources indicate teens want training on how to perform their job tasks effectively and safely. Teens believe injuries result from working with hazardous equipment; performing dangerous tasks; receiving limited, or ineffective, safety training from management; or working for managers who do not care about them or their safety. To a lesser extent, teens believe worker attributes, such as carelessness, foolishness, or not following safety precautions, also contribute to injuries.

Teens recommend several solutions to improve workplace safety. First, teens suggest that managers need to enhance their supervisory skills; understand employees' tasks and responsibilities; know and adhere to child labor laws; and provide better training. Second, management needs to minimize teens' exposure to workplace hazards by providing protective equipment and re-structuring the work environment. Third, management needs to reduce the potential for assaults by hiring more security guards and limiting late work hours. Lastly, teens believe they need to take more responsibility for their safety by using common sense, reading assigned training material, and following prescribed safety precautions.

Conclusions. Working teens suggest a range of interventions that management could employ to structure a safe working environment.

Qualitative Assessment of Teens', Parents', And Employers' Knowledge, Attitudes And Behaviors Related to Adolescent Occupational Safety—Miara C

Introduction. Prevention of occupational injuries to youth requires the combined efforts of employers, schools, parents, and youth. We developed a community-based educational intervention in Brockton, MA, that enlists all these groups in prevention efforts.

Purpose. There are few youth-focused occupational safety materials and little information on what kinds of materials and activities are effective with teens, their parents, and their employers. Therefore, we began the project by conducting focus groups to 1) assess knowledge, attitudes and practices with regard to occupational safety 2) determine the messages and the methods of delivering them and 3) generate ideas for expanding and evaluating our program.

Method. We held five focus groups with students, two with parents, three with employers, and 12 structured interviews with community groups. Cape Verdean, Haitian, and Hispanic populations were included. Each group was asked about workplace hazards, child labor laws, and the employer/employee relationship. A trained moderator, assisted by a notetaker, led each one hour group, using

six structured questions. Focus group transcripts were analyzed by identifying key words and concepts and organizing the responses in terms of the themes described above.

Findings. Comparison of the knowledge, attitudes, and experiences of parents, teens, and employers reveal both similarities and differences. An example is child labor laws (CLL's). Teens and parents were unclear on the laws regarding hours and were very confused about the work permit system. Parents and teens provided many examples of teens being asked to do tasks or work hours that are prohibited by CLL's. Unlike parents, many teens felt the laws restricting teens' work hours are unfair. Employers stated teens may work in violation of CLL's because of the employers': lack of knowledge of the laws; lack of awareness of the age of some of the employees; and attitude that some of the laws are unfair and outdated.

Conclusions. Parents, teens and employers have varied perceptions about work place safety. The results emphasize the need for comprehensive, consistent educational messages. Given limited resources, focus groups are an important vehicle to develop effective materials and refine community interventions.

***Evaluation of a Comprehensive Community-Based Program to Prevent Work-Related Injuries to Teens*—Miara C**

Introduction. A program's evaluation assesses its implementation and effectiveness. Multi-level evaluations of community-based injury prevention programs—especially those targeting occupational injuries—are rare.

Purpose. Changes in injury rates may be an unrealistic measure of effectiveness for programs with limited resources and time. A program's implementation may create increased reporting of injuries. Other strategies for evaluating injury prevention programs are needed. Research from community-based disease prevention/health promotion projects indicate that changes are best achieved through interventions at all levels of the community—from individuals through organizations and ultimately in policy and legislation.

Method. During a two-year period, we implemented a multi-faceted, community-based occupational injury prevention program involving youth, parents, employers, and community organizations. The design of the intervention and the evaluation were based on the Spectrum of Prevention, a six tiered model that integrates individual and environmental change. Components address individual knowledge (school-based curricula), community education, provider training (peer leaders, teachers, health providers, employers), coalitions and networks, organizational practices, and policy and legislation. We developed objectives for each tier, and process and outcome measures for each objective. The evaluation was approximately 25% of the budget and included qualitative (structured interviews, focus groups, detailed project records) and quantitative methods (pre and post surveys of high school students, employers and health care providers, work permit application rates).

Findings. We will present the conceptual framework of our evaluation, examples of process and outcome measures, results, and lessons learned. The evaluation will show that the project had greater impact at some levels (for example, organizational) than at others (such as community education) and will demonstrate the

extent to which the project activities will become institutionalized beyond the two years of the grant.

Conclusions. Using the Spectrum of Prevention model to design an evaluation of a community-based injury prevention project allows project staff to assess changes beyond the level of individual knowledge and behavior, throughout all levels of the community. It also helps in identifying a variety of evaluation measures to use within the constraints of funding timelines and available resources.

***Training to Reduce Hazards in Youth Work: Results from the Brockton Survey of Teenage Occupational Safety*—Bowling JM., Runyan CW, Miara C, Davis L, Dewey R, Gallagher S**

Objective. Occupational injury research has recently focused attention on the perils of youth employment. NIOSH estimates that nearly 200,000 adolescents are injured at work every year. Little is known about hazards that teens face on the job, or current training practices conducted by employers designed to reduce the risks of teen occupational injuries. This study examines the overall distribution of teenage workers involved in jobs that require handling money and toxic chemicals, working with machines, lifting as a regular part of their jobs, and working on ladders or scaffolding. This study also identifies which teens involved in the preceding tasks have been trained while on the job and presents sociodemographic comparisons between trained and untrained working teenagers.

Methods. The study used a cluster sampling method to select classrooms of students from a high school in Brockton, Massachusetts. Students in grades 9-12 completed self-administered questionnaires addressing work practices, knowledge, and injury experience. This study focuses on currently working or previously working youth (N=308) from the Brockton survey.

Results. Most teens have been trained in how to do their jobs (91%) but few have been trained in specifics of reducing the threat of occupational injury. One-half of Brockton teenagers work with money, but only 46% of these youth have been trained on what to do during a robbery. Two-thirds work with chemicals as part of their jobs, but only 41.5% of those who work with chemicals indicate specific training relative to the task. Slightly more than one-third of Brockton working teens work with machines, with 66% of those teens trained. More than one-half are regularly called upon to lift (empty trucks or stock groceries) but only 41% of youth who perform lifting tasks are trained in proper technique. About one-third of the teenagers in the study indicated that they worked on ladders or scaffolding but only 42% of those teens had been trained. Females were more likely to work with money and less likely to work with jobs involving the other hazards. Those females who worked with chemicals were less likely to need training and those who worked in jobs requiring lifting were more likely to need training. Age was not significantly related to any of the potentially hazardous tasks. Industry (grocery, restaurant, other retail, and other industry) was significantly related to both the types of potentially hazardous tasks that teenagers perform and deficits in training associated with these tasks.

Conclusions. Most working youth in Brockton performed potentially hazardous tasks while on the job. A large percentage of these youth had not been trained to do their jobs safely. The propensity to perform hazardous tasks on the job varies by gender as does the likelihood of receiving safety training. Age, codified in law as a

distinguishing factor in teenage job and task delineation, was not found to be an important predictor of performing potentially hazardous tasks. Hazardous tasks as well as deficits in the training of adolescents associated with these tasks tend to be concentrated in certain industries.

Development of Specific Guidelines for Adolescents' Work in Agriculture: Results of a Pilot Study—Lee B, Marlenga B, Hanna C

Adolescents are often injured while conducting agricultural work that may be beyond their physical and cognitive abilities. In 1996 the National Committee for Childhood Agricultural Injury Prevention recommended that guidelines be developed to assist parents and employers in assigning safe, appropriate farm work to children and adolescents. Given the complex nature of agricultural work and the controversial aspects of establishing age guidelines for specific tasks, a pilot study (funded by the CDC-Injury Center at the University of Iowa) was conducted over a 10 month period to determine the feasibility of embarking upon a large-scale initiative to develop "North American Guidelines for Children's Agricultural Tasks."

The overall goal of this initiative is to reduce the risk of fatal and nonfatal agricultural injuries to children younger than 16 years who are conducting farm work. Specific aims of the pilot study were to: a) investigate current information on age- and developmentally-appropriate agricultural tasks for youth; b) identify an effective method for generating comprehensive guidelines applicable to agriculture across North America; c) identify farm parents' perspectives on preferred options for receiving agricultural work guidelines for youth; and d) propose a full-scale initiative based on evaluation results of the pilot phase.

Pilot study methods included: a) a comprehensive review of international literature, farm safety bulletins, and anecdotal notes and reports; b) telephone and in-person meetings with 14 primary advisors; c) written communications with 24 secondary reviewers; and d) focus groups with farm parents.

Results of the pilot study revealed that: a) agricultural work guidelines for youth, based upon empirical data, do not exist; b) the job task analysis framework used in industry is most useful in depicting relevant variables; c) content regarding specific tasks is best obtained from a worker actively engaged in that agricultural enterprise; d) while most child safety advocates are eager to collaborate, the most meaningful input is obtained from agricultural safety specialists; e) given the time constraints of most people, a small group of paid consultants/collaborators is most efficient in working productively; and f) farm parents have mixed feelings about using guidelines for children's agricultural work, but are most interested in receiving information that is brief and reader-friendly, such as a poster to place in the work setting.

Pilot study results provided valuable information that was used to: 1) secure funding from NIOSH and the Maternal and Child Health Bureau (MCHB) to convene a project team comprised of our staff plus 10 paid consultants from the United States, Canada, and Mexico; 2) establish a practical methodology for generating, reviewing, and field-testing about 100 different agricultural work guidelines; and 3) upon completion of field-testing and final approval of the content by the project team, prepare for multimedia

dissemination of agricultural work guidelines to a variety of stakeholders.

This presentation will briefly describe the results of the pilot study and then explain the current status and specific process of this five-year initiative that is now being funded by NIOSH, MCHB, and private sector support.

Session 26: Occupational Eye Injuries

Acute Eye Injury in the Workplace—Jackson LL, Berandinelli SP, Geidenberger CA, Johnston JJ, Long DJ, Layne LA, Islam S

Acute eye injuries continue to occur in the workplace despite being a preventable injury. The U.S. Bureau of Labor Statistics (1996) reported that private industry eye injuries in 1994 accounted for 3.7% (about 83000 incidents) of all nonfatal injuries involving a day or more of lost work. Eye injury and illness incident rates varied greatly among industries with the construction industry having the highest incident rate (29.0 incidents/10,000 full-time workers), about three times higher than the average rate for all private industries (10.4 incidents/10,000 full-time workers). Despite the high incidence rate of eye injuries in some industries, relatively little information is available about industry-specific eye injury risk factors, effectiveness of prevention measures, and associated medical treatment and lost work time.

In order to develop a better understanding of occupational eye injury, we examined data from three sources: the West Virginia Workers' Compensation Program (WVWCP) for work-related injury claims for July 1995 through June 1996; the 1988 National Health Interview Survey (NHIS) for self-reported injuries and medical treatment that occurred during a one-year period; and the National Electronic Injury Surveillance System (NEISS) for emergency department reports for the one year period October 1995 through September 1996.

Eye injuries accounted for 7.6% of the annual compensable claims (4422 eye injury claims/58,325 total claims) in the WVWCP. The number of eye injuries reported in the NHIS correspond to an estimated 626,000 eye injuries for a 12-month period. This represented 5.9% of the estimate for all work-related injuries (10,600,000) for the same time period. Forty-three percent of NHIS respondents with eye injuries filed workers' compensation claims which suggests that there may be a more than two-fold under-reporting of eye injury when restricting analyses to only workers' compensation claims such as in WVWCP.

From NEISS records, work-related eye injuries were about 7.1% (240,000) of all injuries (3,380,000) treated in emergency departments for the one-year period examined. Thirty eight percent of self-reported eye injuries in NHIS were treated in a hospital emergency department in 1988. Extrapolation of the NEISS emergency department eye injuries, assuming that these injuries represent 38% of all medically treated eye injuries, suggests that there are 632,000 work-related eye injuries annually in the U.S. Because of under-reporting of work-relatedness in emergency department visits, this latter estimate is likely to still be an underestimate of the true number of work-related eye injuries. The three injury perspectives uniformly indicate that a significant proportion of occupational injuries are eye injuries—a largely preventable work-related injury.

Epidemiology of Ocular Injury in a Major U.S. Automotive Company—Lincoln A

Purpose. Although occupational eye injuries account for a large proportion of ocular injuries in adults, little epidemiological data in specific industries have been published. To address this problem, we examined the epidemiology of eye injuries among employees of a major automobile corporation. The purpose of this study is to establish data on industry-specific rates of ocular injury and identify problem areas in eye injury prevention in the workplace.

Design. All persons employed between July 1989 and June 1992 in the corporation's assembly, power train, stamping, and parts depot facilities were included in the study. The population was derived from a total of 33 plants situated over the continental United States. Ocular injury data were obtained from an active surveillance system at a major automotive corporation. Incidence data included demographic characteristics of the injured workers (job class, gender, age, length of service) and case characteristics (nature of injury, body part, object involved). In addition, narrative free text fields in the description of the injury and the activity preceding the injury allowed us to go beyond the limitations of coded data to understand the specific circumstances of the injury. Year end employee censuses were used to estimate the population at risk. Outcomes from the ocular injury included: 1) OSHA restricted duty days; 2) OSHA lost days, 3) temporary transferred days, and 4) whether no alternative work was available in the plant.

Results

1,983 work related eye injuries occurred over a three year period, from July 1989 to June 1992. The incidence rate was 14.9 injuries per 1000 person years. Workers between the ages 20-29 had the highest age-specific incidence of 28.2 injuries per 1000 person years. Males had a higher incidence than females across all ages, with an age-adjusted incidence of 15.6 injuries per 1000 person years and age-adjusted relative risk of 1.53 (95% confidence interval, 1.43, 1.64). External foreign bodies and corneal abrasions made up 86.7% of all injuries, while penetrating eye injury occurred in only 3 cases. Almost one third of ocular injuries resulted in the inability of the worker to resume his normal duties.

Conclusion

A high incidence of workplace eye injuries occur among employees of the automotive industry. Although the vast majority of injuries were minor, they account for significant avoidable lost productivity. While the apparently high incidence in automotive workers may be due to higher risks inherent in this industry, it could also be due to the inclusion of previously under-reported minor injuries not requiring medical attention at hospitals. The high proportion of injury related to grinding, welding, and use of air tools reemphasizes the need for eye protection in these activities. The high proportion of paint-related chemical injuries suggests the need for eye protection in workers exposed to such substances.

Nature of Construction Industry Eye Injuries Treated in Emergency Departments—Long DJ, Layne LA, Jackson LL

For most of the last twenty years the construction industry has had the highest rate of nonfatal serious injury of any U.S. industrial sector (U.S. Bureau of Labor Statistics). Our analysis of emergency department cases recorded in the National Electronic Injury Sur-

veillance System (NEISS) indicated that emergency medicine departments treated an estimated 240,300±51,800 (CI95) work-related eye injuries in the United States from October 1995 through September 1996. Of those eye injuries 16% (37,700±12,600 CI95) occurred to construction workers. Eye injuries represented 11% of all types of traumatic injury among construction workers. We are studying the epidemiology of eye injuries among injured construction workers from this national sample to determine risk factors for specific occupations and work tasks that will lead to better eye injury prevention strategies.

NEISS is a national stratified probability sample of all hospitals in the United States that provide 24-hour emergency department services. Four hundred thirty-three case records were collected for construction worker eye injuries from October 1, 1995 through September 30, 1996 from 65 nationally sampled hospitals through a collaborative agreement between the Consumer Product Safety Commission and the National Institute for Occupational Safety and Health. Each NEISS injury record contains demographics of the injured worker, occupation and industry information when available, and a narrative description of the injury incident. From the narrative description of the injury, we further coded work activity, tools used, materials handled, and outcome of injury. Using a statistical weighting factor for each case we calculated national estimates for various eye injury characteristics. Confidence intervals were calculated using simple linear expansion to account for the complex sample design.

Nationally, 98% (37,100±12,400 CI95) of these construction eye injuries occurred to males. Forty-one percent (15,500±8,000 CI95) of all workers were 20 to 29 years old and 33% (12,300±3500 CI95) were 30 to 39 years old at the time of injury. Seventy-eight percent (29,400±12,000 CI95) of the injured workers were white, and 5% (1,700±1,000 CI95) were black. Most eye injuries occurred to relatively young, white male construction workers following the general demographic trends for the construction industry.

For all eye injuries, about 70% were foreign bodies in the eye, 13% were struck by injuries, and 6% ultraviolet burns or keratitis. Although the details of work activity at the time of the injury were frequently missing from these surveillance system records, several common construction tasks were identified that resulted in eye injuries. For example, sawing was indicated as the work task for 16% of the foreign body eye injuries and hammering or pounding was indicated in 10% of the struck by injuries. In 91% of the ultraviolet burn cases, the injured person was clearly identified as either welding or in the area of someone else welding at the time of injury.

A large number of these injuries are preventable. Although the majority of the injuries are relatively minor, they still represent a significant loss of productivity and medical expense that are avoidable through better engineering controls and utilization of proper eye and face protection.

Work-Related Eye Injuries Among Union Carpenters 1989-1995 Lipscomb HJ, Dement JM

Union administrative records were combined with workers' compensation data to identify a cohort of union carpenters, their person-time at risk, and their documented work related eye injuries between 1989 and 1995 in the State of Washington. The injuries were described using ANSI codes for injury nature, type (mecha-

nism), and source or object associated with the event. Injuries were also described based on the ICD9 codes attached to claims for the treatment of these injuries. Overall rates of filing compensation claims for eye injuries as well as age, gender, and union local specific rates were calculated. Kaplan-Meier lifetable analyses were used to compare time to the first and second eye injuries based on person-hours of work as a union carpenter. To identify high risk subgroups, the person time and events were stratified by age, sex, time in the union, and predominant type of work of the union local with which each carpenter was affiliated for multivariate analyses with Poisson regression.

Results. A cohort of 13,553 carpenters was identified each of whom had worked at least 3 months of union time during this seven year time period. Eye injuries were responsible for 14% (n=1866) of all claims filed during this time period, second only to back and finger injuries. Using ANSI code descriptions from the first report of injury, the types of events most commonly associated with eye injuries were abrasions (74%), being struck (20%), contact with a toxin (5%), or contact with a hot object (<1%). Based on nature of injury codes, 83% of these injuries were described as scratches, followed by conjunctivitis (4.4%), cuts (4.3%), welder's flash (2.4%), contusions (1.9%), ill-defined conditions (1.7%), and chemical burns (1.2%). The ICD9 codes assigned to these claims were consistent with these descriptions with the vast majority described as foreign body on the external eye (44%), superficial injury of eye/adnexa (28%), or disorders of the conjunctiva (7%). Much less common were more serious open wounds (1.4%) and burns of the ocular adnexa or eyeball (2.7%). Less than 2% of the claims resulted in medical costs of over \$500 and these cases accounted for nearly a third of all costs for medical care and 90% of lost work days. Twenty-five percent of these serious cases involved metal fasteners.

Claims for eye injuries were filed at a rate of 5.7/200,000 hours worked. Recurrent eye injuries occurred at a rate approximately two times higher than incident claims. Poisson regression analyses revealed no significant differences in the rate of eye injuries by gender. The rates of eye injuries decreased significantly with age and time in the union. Elevated rate ratios were seen for drywall workers and residential carpenters (RR=1.2).

The findings identify some high risk groups (ie., young, inexperienced, drywall workers and residential carpenters) and raise questions about factors which might influence the failure to use appropriate protection including availability and acceptability of eye protection, use by peers, and perception of risk. Eye injuries among these union carpenters were very common, but the rate of severe injuries was quite low. Perceived risk has been reported to be more likely to be influenced by severity of injury than by injury frequency. The high rate of recurrence may be a reflection of lack of perceived risk among workers.

The findings identify some high risk groups (ie., young, inexperienced, drywall workers and millwrights) and raise questions about factors which might influence the failure to use appropriate protection including availability and acceptability of eye protection, use by peers, and perception of risk. Eye injuries among these union carpenters were very common, but the rate of severe injuries was quite low. Perceived risk has been reported to be more likely to be influenced by severity of injury than by injury frequency. The high rate of recurrence may be a reflection of lack of perceived risk among workers.

Follow-up Study of Eye Injuries Among Construction Workers Catalina LC, Hunting KL, Welch LS

Occupational eye injuries are common and preventable. Since 1990, we have conducted surveillance of construction worker injuries treated in George Washington University's Emergency Department. During that time, eye injuries have constituted 11% of our construction worker cases. Our surveillance data has shown that workers who operate power tools and who do overhead work are at risk of eye injuries (predictable), but also that co-workers working in close proximity to these tasks also experience eye injuries (not as predictable). Plumbers and painters had a higher proportion of eye injuries than other trades. Another observation was that, in some trades, traditional construction workers had different patterns of eye injury than fixed site (maintenance) workers.

In 1996, we designed an eye injury questionnaire and began conducting short-term telephone follow-up interviews (within 4-8 weeks after the injury) to further explore circumstances of eye injuries and workers' attitudes/behavior regarding the use of eye protection. We hope to identify specific risky tasks across construction trades, and explore factors which might account for differences in the eye injury experiences of maintenance workers and traditional construction workers.

Data will be presented from interviews with approximately 30 construction workers. The circumstances of their eye injuries vary, and illustrate some high-risk activities typical of construction work. An almost universal result, however, was lack of eye protection, or lack of appropriate eye protection (for instance, protective eyewear lacking side shields). Workers also reported, almost universally, that they were unaware of any job site policies for mandatory eye protection on the jobs on which they were injured.

The eye injury follow-up study is prevention oriented. In the future we hope to be able to use the results to design jobsite interventions to help reduce the number of eye injuries in the construction injury.

Session 27: Office Ergonomics and Human Performance

Effects of Alternative Geometry Keyboards on VDT Users with Work-Related Musculoskeletal Disorders: Part I - Clinical Outcomes—Burastero SR, Tittiranonda P, Rempel D

Aim. Within the past several years, a variety of alternative split geometry keyboards have been designed with the goal of increasing user's comfort and reducing the posture-related risk factors associated with work-related musculoskeletal disorders (MSDs). Short-term laboratory studies, ranging from 20 minutes to 2 days have shown that these keyboards can achieve the objectives of altering forearm postures (Burastero 94, Rempel 94) and reducing muscle activities (Gerard 94). To date, no long-term studies have evaluated the effectiveness of these keyboards in preventing or managing WRMSDs during long term use. The study aimed to determine the long term health effects of four computer keyboards on VDT workers with work-related MSDs based on physical examination, hand function and subjective pain reporting.

Method. Eighty workers at the Lawrence Livermore National Laboratory who used the keyboard >20 hours per week and had no pre-

vious exposures to the alternative keyboards were randomly recruited from the onsite's workers' compensation injury database. Eligible subjects were diagnosed with carpal tunnel syndrome and/or tendonitis according to a standardized physical examination. Subjects were randomized to 4 keyboard groups (n=20/ group): the Apple Adjustable [kb1], Comfort Keyboard System [kb2], Microsoft Natural [kb3] or conventional (placebo) keyboard. Questionnaires on upper limb symptoms, hand function, pain and discomfort and a physical exam were administered prior to the keyboard intervention, and 6, 12, 18, and 24 weeks after heavy keyboard use.

Results. Over three months, overall pain and functional status among employees with WRMSDs improved when using all alternative geometry keyboards, with significant improvement observed for kb3 group. Hand function improved significantly for all alternative keyboard groups but remained unchanged for the placebo group. Following six months of keyboard use, a positive trend toward improvement in pain severity and hand function was demonstrated in kb3 and to a lesser extent kb1 compared to the placebo. This study provides evidence that some alternative geometry keyboards can be useful to some employees suffering from WRMSDs in reducing symptom severity and improving functional status.

Effects of Alternative Geometry Keyboards on VDT Users with Work-Related Musculoskeletal Disorders: Part II - Productivity and Long Term User Comfort—Tittiranonda P, Burastero SR, Rempel D

Aim. A variety of alternative split geometry keyboards, which were developed to increase user's comfort and reduce the posture-related risk factors associated with musculoskeletal disorders (MSDs) have become commercially available. Laboratory-based performance and preference studies have examined the effects of these keyboards on subjects over short time periods, ranging from 20 minutes to 2 days (Swanson 97, Cakir 95, Gerard 94, Burastero 94). Other workplace studies have also investigated the effects of split keyboards on performance, preference and wrist postures among asymptomatic typists after 2 to 6 weeks of keyboard use (Cakir 95, Tittiranonda 94). To date, no long-term studies have evaluated the effectiveness of these keyboards to increase comfort among computer users with hand pain. The purpose of this study was to evaluate the effects of 4 keyboard designs on short-term productivity and long-term comfort and preference in computer users with musculoskeletal disorders.

Method. Eighty computer users at the Lawrence Livermore National Laboratory who participated in the prospective randomized, placebo controlled trial of computer keyboards (Part I) were asked to participate in a typing experiment on the day of randomization. At their own workstations, their productivity (speed & error) on their usual conventional keyboard and the assigned alternative geometry keyboard were recorded. Subjects first typed for 15 minutes on their own conventional keyboard (three 5 minute sessions with 1 minute break after each trial), then on their assigned keyboard for three additional sessions. A 15 minute break was given after completing all sessions on one keyboard. Calculated productivity on the alternative keyboards was normalized to the average productivity on the subject's usual keyboard (mean productivity ratio, MPR). Those who could not achieve >80% mean productivity ratio participated in a follow-up typing test after 2 weeks of

keyboard usage, where they underwent three additional five minute sessions. Subjects used the assigned keyboard for 6 months. At the end of the trial, they compared their assigned keyboards to their usual conventional keyboard using a series of 10 cm visual analog scales with anchors of "much worse" [0], "same" [5] to "much better" [10]. The keyboard characteristics rated were (1) keying force required (2) keying action (3) ease of use (4) ease of learning (5) effort required during keying (6) hand/wrist comfort (7) arm/shoulder comfort (8) overall postures required (9) overall design and (10) overall rating.

Results. Computer users assigned to kb1 and kb3 were able to achieve >=95% of their performance on the conventional keyboard after 15 minutes of typing. Following six months of use, the highest comparative comfort ratings were reported by subjects who used kb3, while the lowest rating were reported by those assigned to the placebo. Kb3 received that highest comparative rating for ease of learning, while kb2 was rated the lowest. Subjects who used kb1 felt that it required significantly less effort than the conventional keyboard. Overall, kb3 received the highest comparative rating for its design, followed by kb1, the placebo and kb2.

The Nature and Role of Human Factors as Risk Factors for Occupational Injury—Feyer A, Williamson AM

It is generally agreed that human factors are a major component of the causes of occupational accidents in the workplace. However, our understanding of the exact nature of their role has been slow to develop beyond acknowledging their prevalence. Part of the problem arises from the complexity of such a large category. In general, the term human error has been used rather broadly to encompass all of the ways in which the human factor can contribute to injury occurrence through direct unsafe acts at the time of the injury event. In fact, the nature and timing of behaviour, be it error or not, and the involvement of routinely unsafe work practices all need to be considered as do the network of relationships between human factors and between human and other causal factors. Better understanding of how, why and when human factors occur in the circumstances leading to occupational injury is the critical precursor to making predictions about the role and the prevention of this major risk factor.

Recently, a classification system has been developed which was designed to both describe the complex network of events leading to occupational injury and also to evaluate the relative importance of events in causing the injury event. The system covers the wider circumstances of the injury event including both the events that lead directly to the injury event and any other contributing factor and attempts to provide comprehensive classification of the potential range of human behaviour involved in injury causation. Thus, ongoing but unsafe work practices are distinguished from errors and errors are classified in some detail according to two well-known classification systems. As well, particular attention was paid in the system to comprehensive coverage of the range of non-human factors possibly involved.

To date the classification system has been applied extensively to the analysis of the information surrounding the occurrence of all work-related traumatic fatalities in Australia over the years 1982-1984. The data were obtained from the information in coronial records collected as part of the Work-related Fatalities Study undertaken by the National Institute of Occupational Health and

Safety. Analysis of this large heterogeneous data-base of work-related fatalities revealed that most fatalities had a discernible causal sequence and that in the vast majority of cases more than one cause was involved. However, two thirds of the cases involved one of only 4 main patterns of causation, consisting of either behavioural events, environmental events or a combination of the two. The analysis revealed human behaviour in general was the most common and the most influential causal factor. However, in terms of targeting prevention strategies, the relationship between factors proved to be among the most promising findings. Pre-existing work practices, for example, provided the most common circumstances for later errors, particularly those occurring during highly skilled behaviour to have their impact. The latter are not amenable to prevention while the former are eminently so. Further analysis revealed that while this pattern was common for most industries, some notable exceptions were evident, specifically timbergetters and workers in electrical trades.

It is commonly believed that occupational accidents are the outcome of a complex network of inter-related events in which human factors play a vital role. The present findings provide empirical evidence for these beliefs, and in particular, for the diverse role of human factors in the occurrence of occupational injury.

The Relationship Between Behavior and Injury in a Lumber Mill—Krause TR, Seymour K

When a company uses a behavior-based safety initiative that incorporates the use of operational definitions of critical safety-related behavior, standard observation scoring techniques, effective interactions between observer and worker, and systematic use of behavioral data for problem-solving, they can expect to see significant reductions in injury rates and strong relationships between behavioral process indicators and injury frequency. The purpose of this study was to demonstrate that the behavioral data generated from this process at a lumber mill were correlated with injury rate. It was hypothesized that percent safe behavior and contact rates at this lumber mill are negatively correlated with recordable injury rate. The subject of this case study was a 425-employee lumber mill whose employees began behavior-based safety observations in April 1994. Data were collected from April 1994 through March 1996. The variables measured were percent safe, contact rate, and recordable injury rate. Percent safe was defined as the overall percentage of safe behavior recorded on data sheets and entered into software each month. Contact rate was defined as the total number of employees observed each month divided by the total number of employees covered by the behavior-based safety initiative. Recordable rate was defined as the number of injuries and illnesses recorded on the OSHA 200 log each month, multiplied by 200,000 and divided by the number of hours worked. These data were screened and analyzed using SPSS software. As the percentage of safe behavior increased, the recordable injury rate decreased. This finding was statistically significant ($r = -.47, p < .02$). Similarly, as the contact rate increased, the recordable injury rate decreased. This finding approached significance ($r = -.31, p < .07$). Having a valid upstream measure of safety performance is crucial for preventing injuries before they occur. The instrument which observers at this lumber mill developed and used for recording safe and at-risk behavior was an excellent predictor of injury frequency. This allowed them to use the data in problem-solving with confidence that their efforts would make a difference. Furthermore, the more feedback about their safety performance employees received (higher contact rate) the fewer injuries that occurred. This reinforced ob-

servers' confidence that their efforts had a direct and immediate effect on safety at their mill.

Session 28: Risk Factor Analysis—Methods and Perspectives

Analysis of Injury Risk Factors with Neural Networks—Landsittel D, Arena VC

Neural networks have been shown to be a valuable analysis tool in research areas such as information science. Recent work has indicated that neural nets may also be useful in prediction and classification of biostatistical data. The importance of this research is to outline and illustrate how neural networks can be implemented to assess the statistical significance of injury risk factors and predict the probability of injury given individual characteristics. The output of the network is interpretable as the probability of an outcome, such as injury. The likelihood ratio test is used, in conjunction with a selection algorithm, to assess the statistical significance of injury risk factors. An overview of traditional methods for model selection and classification of injury data is presented and the advantages and disadvantages of using neural networks to analyze injury risk factors are examined.

Neural networks are a type of nonlinear regression where the nature of the association between the covariates and outcome is not explicitly specified. The form of, and interaction between variables are also implicitly fit in the model. Both positive and negative implications of the previous statements are investigated. In cases where the nature of the association between injury and possible causal factors is unknown, neural networks may provide an effective alternative to standard methods. Since neural nets depend on an iterative routine to solve for the optimal weights, the solution may only represent a local minimum and the fact that a particular association is not explicitly specified may lead to over fitting the data. These and other possible limitations of neural nets are explored specifically with respect to analysis of injury risk factors. Several methods to improve the performance of neural networks, including weight decay, committees of networks, and cross validation are illustrated. General conclusions about the role of neural networks in injury risk factor analysis are made.

Epidemiologic Confusion in Injury Research—Park B

Epidemiologic approaches to injury research frequently apply methods that were developed for chronic diseases where individual case attributability must be inferred, whereas with workplace injury, work-attributability is self-evident. Exposure definition, on the other hand, is much more straight-forward in traditional chronic disease epidemiology (although retrospective retrieval is difficult) than for injuries, where exposures can be transient circumstances that arise in machine or system failures and that are inherently poorly understood. Very few occupational injury studies have actually defined and measured exposure risk factors in a factory environment, with the possible exception of studies involving industrial vehicles. Instead, most attention is focused on risk modifiers which, while potentially informative and useful in the context of well-described exposures, are essentially uninterpretable in the absence of same. Descriptors such as age, seniority, gender, job classification, behaviors, etc. are all confounded by the exposures that cause injuries. Insights into describing injury exposure come from examining individual events; examples will be presented from UAW fa-

tality experience. Methods to identify and quantify injury exposures could include use of management maintenance information systems (MMIS), now common in many plants, which record all specific work orders in considerable detail. Another approach would be to do random work sampling, possibly making use of portable data-loggers.

Case-Crossover Pilot Study of Traumatic Occupational Injury to the Upper Extremities—Sorock G, Hashemi L, Cotnam J, Mittleman M

Traumatic occupational injuries of the upper extremity (mostly lacerations, contusions, and burns) are common, accounting for about 30% of visits to hospital emergency departments for occupational injuries in 1996 (NEISS data), and about 10% of all workers compensation claims in one insurance company in 1992. Few analytical epidemiologic studies of these injuries have been reported in the medical literature. The existing data suggest that work with machines and knives or tools increase the risk of such an injury especially when a work process (machine or stock) gets jammed/stuck or is unusual in some manner. We therefore plan to undertake a case-crossover study of risk factors for traumatic occupational injury to the upper extremity.

The case-crossover design is an emerging epidemiologic approach for studying transient risk factors for acute onset events such as traumatic injury. It can help answer the question: Was the injured person doing anything unusual before the injury occurred? For example, the subject may be asked about specific work conditions during a relevant time window just before the injury (perhaps 10 minutes), and asked about the same work conditions during a comparison 10-minute period one hour before the injury, and about the usual frequency of the same condition during the past month. Whether the condition was present just before the injury, and not at an earlier time period (or vice versa), is the key measure in such a study. Each subject acts as his or her own control thereby eliminating confounding by constant subject characteristics such as age, gender, work experience and injury history.

We will report some preliminary results of a case-crossover pilot study of occupational traumatic injury to the upper extremities in two manufacturing plants. In both sites, injury log data were reviewed and analyzed to develop injury scenarios for machine, knife or product related past injuries. A total of 30 subjects will be interviewed during the summer of 1997. Some interviews will be done in person by the occupational health nurse following treatment of the injured worker on site. Other interviews will be done by telephone within hours after the injury by Liberty Mutual trained interviewers. Progress and difficulties with the actual pilot test will be summarized. Plans for expansion of the study will also be discussed.

Workers Having 20 or More Workplace Accidents - Identification of Characteristics as the First Step to Developing Effective Injury Reduction Interventions—Gallie KA, Jessup BA

Introduction. A retrospective analysis of the injuries reported to the British Columbia, Canada Workers' Compensation System from 1917-1995 showed that 15,042 workers have experienced 20 or more workplace injuries over their working lifetime. In order to develop a better understanding of the factors associated with re-

peat accidents additional analysis into occupation and injury patterns along with file review and worker/employer feedback was conducted. This information has been used to develop multi-partner interventions to ensure that others do not enter this at "High Risk" group (i.e., for disability and a 10 times greater chance of fatality). Here we report injury/occupation profiles as well as the organization of work and work environments involved. The Preventing Accident Repetition Program Interventions and Findings are reported in part 2.

Findings. To date, 1 percent of workers having reported an injury to WCB-BC have experienced 20 or more workplace accidents ($n = 15,042$; $X = 25.4$ injuries/worker per working lifetime, range = 20 - 91 injuries; $SD = 10.9$). The average age of these workers was 53 years (range = 25-80; $SD = 12.3$) and they averaged 1.68 new injuries/year (range = 0-38; $SD = .99$). The majority of these workers were male. Most had occupations in the machining, fabricating, assembly and construction trades. Less than 2 percent were from clerical/sales, teaching occupations.

Most injuries were to the lower back, finger/hand and knee areas caused by overexertion and falls. Many of these injuries were reported as sprains and strains, cuts and lacerations, rather than carpal tunnel, concussions, fractures and amputations. No significant monthly or weekday variation in injury incidence was detected.

Investigation into accident processes uncovered heterogeneous factors. For some workers the type and mode of injury was largely occupation based. For example, steelworkers/welders largely reported metal particles in their eyes, stevedores reported back, knee, and shoulder injuries sustained by falling/slipping. For others there appeared to be stronger psychosocial factors involved, especially in the case of fatalities (i.e., economic and family pressures) and where the age at first injury was very young (i.e., 9 - 16 years; assault/multiple trauma incidences). Our data also shows that at "High Risk of Re-injury" is also an employer attribute as there are typically numerous 20+ workers/job site. Concerns voiced by these workers and their employers guide us in our understanding of some of these injury-re-injury dynamics and provide our direction in the development of intervention strategies. Common concerns of 20+ workers include upper management/supervisor attitudes and knowledge towards Occupational Health and Safety, stress in the workplace, as well as co-worker/supervisor activities (i.e., drug and alcohol, harassment etc.). Employer responses are more varied and range from blaming the worker to those who realize the complexities and necessity of partnership in order to produce effective Occupational Health and Safety Programs.

Session 29: Use and Evaluation of Surveillance Systems

Evaluation of an Educational Program to Improve the Sensitivity of Death Certificates in Identifying Occupational Fatalities—Scheerer A, Struttman TW, Moon E

Surveillance of occupational fatalities in Kentucky during 1994 revealed that death certificates showed an 81 percent sensitivity in correctly identifying work-related fatalities based on the "Injury at Work?" field. This result prompted researchers at Kentucky Fatality Assessment and Control Evaluation (FACE), a NIOSH-sponsored project, to initiate a statewide program to increase the accuracy of death certificate data. Beginning in April 1995, coroners

were provided with educational materials, via a series of presentations, mailings and phone calls designed to increase their use of the Operational Guidelines for Determination of Injury at Work (developed by the Association for Vital Records and Health Statistics). To evaluate these efforts and ascertain coroners' knowledge of the Guidelines, a telephone survey of half of the state's 120 county coroners was conducted in December 1996. Results showed that 65 percent of the coroners remembered receiving information from KY FACE; of those, 88 percent rated FACE as having been helpful in providing instruction about determining injury at work. Fifty-five percent reported routinely referring to the Guidelines when responding to the "Injury at Work?" question. To assess how coroners determine work-relatedness, they were presented with brief scenarios of fatal injury cases and then asked how they would complete the "Injury at Work?" box on the death certificate. 1996 data showed that the sensitivity of the "Injury at Work?" box in identifying occupational fatalities had increased to 84.6 percent. Analysis will continue through 1997 to assess the accuracy of the "Injury at Work?" question and further examine the benefits of the educational program.

Wisconsin FACE 1991-1997: On-Site Investigation Findings and Recurrent Themes for Fatality Prevention—Hanrahan LP, Tierney J, Braddee R

As of March 1, 1997, 109 of 629 (17%) fatalities entering the Wisconsin surveillance system met the NIOSH criteria for an on-site investigation. They included 5 confined space deaths, 11 electrocutions, 42 falls, 51 machine related fatalities and one firefighting fatality. From these, a total of 51 (47% of eligible cases) on-site investigations were completed. They included four confined space studies, 8 electrocution investigations, 23 falls, and 16 machine related fatalities. Characteristics were examined and prevention recommendations were summarized for this case series. Farmers were involved in over half of the investigated fatalities, and were represented in each of the in-scope types: confined space (asphyxiations), machines (tractor rollovers, run overs, and machine entanglements), falls, and electrocutions. Causal factors were summarized using the Haddon Matrix and recommendations to prevent similar occurrences were categorized into meaningful groupings. The Haddon Matrix and prevention recommendation analyses are still underway and will be presented at the conference.

Wisconsin FACE: Findings From The First Cycle of Surveillance Activities—Hanrahan LP, Tierney J, Braddee R

Wisconsin is home for 5.1 million residents and 2.5 million workers. Important industrial sectors include service, manufacturing and retail trade; as America's Dairyland, agriculture also plays a vital role in the economy. From October 1, 1991 through February 28, 1997, the Wisconsin FACE program tracked 629 occupational fatalities through its surveillance system. During this period, the Wisconsin workforce averaged 118 fatalities per year, or nearly one fatality every three days. Information on cases was obtained from a network of multiple reporting sources: death certificate (100%); workers compensation (47%); newspaper (42%) coroner's reports (21%); police (18%); and OSHA (11%). Detection and notification steadily improved over time. For 1992 deaths, fewer than 18% of cases were reported in less than a week after the event. In contrast, by 1994 over 43% of deaths were detected by the surveillance program within a week of the event. The majority of cases were male (92%), and white (95%). Over 15% of all cases were

aged 65 and older, while 6 cases were less than 15 years old. As in the 1980's, farmers and agriculture accounted for a large number (29%) of the cases. Transport / drivers represented 16.6%, construction workers 8.5%, professionals 8%, and laborers 7%. The distribution of fatality causes was similar to the 1980's: approximately 24% of the fatalities were caused by motor vehicle crashes, and another 24% were due to machines. Here, agricultural machines (ICD9 E-Code 919.0) represented the majority of machine types. Struck by falling objects accounted for another 9.9%, while falls represented 8.2% of cases. Incidence rates for the time period were constructed by occupation, industry, gender, and age. These were compared to findings from the 1980's (NIOSH - A Decade of Surveillance), and will be summarized at the conference.

The Effect of Workers' Compensation Likelihood on the Reporting of Cumulative Trauma Disorders—Lincoln A, Baker SB, Smith GS

Introduction. Proper reporting of musculoskeletal conditions is imperative to establish the incidence and circumstances of occupational injuries and illnesses and determine priorities for interventions. However, biased reporting practices may be associated with the likelihood of compensation award for specific conditions. For example, in those states which require "a specific incident/accident" for compensation, workers who develop a cumulative trauma disorder may be more likely to describe their condition as an acute strain/sprain, i.e., to cite a specific incident as the source of the problem. The effect of such a potential bias would be to under-report the incidence of cumulative trauma disorders while over-reporting that of strains/sprains, which are considered to be acute injuries. Such an effect could have dramatic impacts on the validity of data used to base decisions regarding ergonomic interventions and measure its effectiveness.

Methods. This study attempts to determine the existence of such a reporting bias by examining state-by-state variations in the proportions of musculoskeletal conditions that are reported as cumulative trauma disorders (CTDs) versus those reported as strains/sprains. A computerized, companywide medical surveillance system was used to ascertain all musculoskeletal conditions within an automaker's U.S. warehouse facilities between January 1991 and September 1996. The 19 facilities are distributed throughout 16 states which vary in their statutory outlook regarding work-relatedness of CTDs and likelihood of accepting workers' compensation claims for CTDs. States were categorized on the basis of: 1) recognition of CTDs either within state workers' compensation statutes, case law, or the definition of occupational disease/injury; and 2) likelihood of awarding compensation for a CTD claim.

Findings. Preliminary findings indicate that in the eight states which do not recognize CTDs in statute, case law, or in the occupational disease/injury definition, CTDs represent 3.4% of all musculoskeletal conditions. This compares with 10.2% among those eight states which do recognize CTDs in some form. Given that any musculoskeletal condition is reported, the odds of a CTD case being reported in a state which recognizes CTDs is 3.26 relative to a state which does not recognize CTDs (95% CI: 2.14, 4.99). A comparison between reports of CTDs and diagnoses that are most likely to be substituted for a CTD (i.e., strains/sprains of the hands/wrists, forearm/elbow, and shoulder/upper arm) yield similar results. For injuries to the hand and wrist, the odds of being reported as a CTD rather than a strain/sprain in a state which recognizes

CTDs relative to a state which does not is 2.79 (95% CI: 1.33, 5.92); for forearm/elbow conditions the odds ratio is 4.42 (1.20, 19.29); for shoulder/upper arm conditions the odds ratio is 4.34 (1.43, 14.73); and for conditions involving the hands/wrist, forearm/elbow, and shoulder/upper arm combined the odds ratio is 3.90 (2.31, 6.65).

Conclusion. The consistency of findings suggests that a significant difference in reporting may exist, possibly related to state workers' compensation policy regarding compensation for CTDs.

Session 30: Occupational Violence

Workplace Violence: Research for Prevention—Jenkins EL

An average 20 workers are murdered and another 18,000 become the victims of nonfatal assaults in the workplace each week in the U.S. While all workers are potentially at risk for such attacks, surveillance data indicate that the largest number of workplace homicides occur in retail trade (38%) and service (17%) sectors. The largest number of nonfatal workplace assaults occur in the service sector (64%), particularly in nursing homes (27%) and hospitals (11%). The highest rates of workplace homicide occur in retail trade (1.60 per 100,000 workers) and public administration (1.30). Homicide is the leading cause of occupational injury death for women in the workplace and the second leading cause of death overall. For homicides, men are at three times higher risk than women, but for nonfatal assaults women are at slightly higher risk than men. Risk factors for workplace violence include dealing with the public, the exchange of money, and the delivery of services or goods. Prevention strategies include environmental designs (e.g., visibility and lighting, cash-handling devices, and bullet-resistant barriers), administrative controls (e.g., staffing plans and violence prevention policies) and behavioral strategies (e.g., training in non-violent response to robbery). There are, however, very little scientific data as to the effectiveness of these strategies in various settings, either alone or in combination. Research on workplace violence (surveillance and risk factor research) is made more difficult by the lack of complete victim, perpetrator, risk factor, and exposure information. The description of the nature and magnitude of this problem has, to date, relied on information collected for other purposes (e.g., death certificates, workers' compensation files) or as part of a larger criminal justice information system (e.g., victimization surveys). Future research on workplace violence will have to address the limitations of existing data and focus heavily on evaluating the efficacy of prevention strategies in various settings.

Evaluation of Risk Factors for Workplace Violence in Liquor Stores—Hartman C, Peek-Asa C, Kraus JK, Erickson J, Howard J

Introduction. Liquor stores have the second highest workplace homicide rates in the U.S., second only to taxicab drivers. The number of nonfatal injuries to liquor store employees is unknown, but likely exceeds the number of fatal events. Workplace violent injuries in liquor stores are due predominantly to robbery and shoplifting, but little is known about the risk factors that make liquor stores especially vulnerable. This study examines the robbery history and risk factors for workplace violence found in a small sample of Southern California liquor stores.

Methods. Robbery and assault histories for liquor stores in Santa Monica, California were collected from January 1992 through July

1996 from the Santa Monica Police Department (SMPD). Owners from 20 liquor stores in Santa Monica were eligible to participate in the study; 12 (60 percent) agreed. Environmental surveys to determine risk factors for robbery and workplace violence injury were conducted in each of the participating liquor stores.

Results. Robberies and assaults are very common among liquor stores in Santa Monica. On average, liquor stores were robbed one time in the four-and-one-half-year time period covered by SMPD records, with a range of 0 to 5 robberies. During the same period, three assault-type offenses were averaged, with a range of 0 to 8 assaults. Robberies accounted for 13 percent of all crimes reported to police by liquor stores; assaults accounted for 60 percent. The survey of risk factors identified many potential areas to introduce prevention strategies, including cash handling, store-front window visibility, indoor and outdoor lighting and training in crime control.

Conclusion. This survey found a number of risk factors for robbery and workplace violence for which interventions could be both inexpensive and easily-implemented. This research is a pilot-study for a large-scale intervention of workplace violence.

Risk Factors for Robbery and Employee Injury in Convenience Stores—Hendricks S, Landsittel D, Amandus H, Malcan J

Homicide is the second leading cause of workplace fatalities. Additionally, the annual number of workplace assaults have been estimated to be one million or more. The majority of these workplace assaults and homicides are robbery related. Convenience stores have been shown to be especially vulnerable to robbery and employee injury. The results of two studies examining the risk factors associated with robbery and employee injury in convenience stores are reported here. The first study consisted of collecting information from police reports of convenience stores in the metropolitan areas of seven states. The purpose of these data was to examine risk factors (use of a weapon by the robber; number of customers in the store at the time of a robbery; gender of a lone employee; the number of employees on duty; the amount of money stolen; time of day of the robbery; the stores past experience with robberies) which are associated with the risk of an injury given a robbery occurs. Results from this study as well as the limitations of using police reports are discussed. The second effort was a case-control study of convenience store robbery in the three largest metropolitan areas in the Commonwealth of Virginia where a case store was a store with a robbery reported to the police and a control store was a store within a 2-mile radius of the case store which was open at the time of the robbery. The purpose of these data was to examine the association of store environmental designs (use of a cash limit and drop safe; location of the cash register; escape routes and hiding places; lighting inside and outside the store; view into the store from outside, within the store, and out from the store; use of security cameras, videos, and security mirrors; presence and location of gas pumps and pay phones), geographical factors (proximity to major highways and traffic routes and amount of traffic; surrounding criminal activity; surrounding land use; socio-demographic characteristics of the surrounding community), and store operational characteristics (number of employees on duty; training of employees in robbery prevention; weapons available to the employees) to the risk of a store being robbed. Results from these data are presented. Difficulties and limitations of assessing factors

associated with the overall risk of injury to employees from these two separate components are discussed.

Washington State's Late Night Retail Worker Crime Protection Regulation: Relationships with Employer Practices—Nelson N, Mendoza CT, Silverstein BA, Kaufman JD

Washington's Late Night Retail Worker Crime Protection regulation, which became effective in February of 1990 and is enforced by the state OSHA program, was intended to prevent injuries by deterring violent crimes in retail establishments. We investigated whether the regulation was associated with businesses' violence prevention activities. 1,516 employers at high risk of robbery, including gas stations, groceries, convenience stores, hotels, restau-

rants, and taverns, were surveyed in 1995 to determine whether they had violence prevention training programs for their employees (a requirement for businesses covered by the standard). Overall, awareness of the regulation was low (4.4%). Employers covered by the regulation were more likely to have training programs (OR=1.4), as were those aware of a regulation (OR=3.4). State OSHA plan contact (in the form of a compliance inspection or consultation visit) was also associated with having a training program (OR=1.9). There was some suggestion that chain businesses were more likely to have programs (more specifically, those chains that had experienced a robbery). Despite low awareness of the standard, results suggested that regulatory efforts to protect high-risk employees were associated with employers' robbery and crime prevention activities.

Day Three--Friday, October 17, 1997

Session 31: Injuries and Fatalities in Retail Trade

Workplace Deaths in the Retail Industry, US 1992-1995—Peek-Asa C

Introduction. In many urban areas of the United States retail is among the fastest growing economic sectors and employs a growing percentage of the overall workforce. Although retail has not traditionally been identified as a high-hazard industry, it is among industries with the highest number of workplace deaths. The Bureau of Labor Statistics reported that 17% of all workplace deaths in 1994 were among retail workers. This presentation will examine workplace deaths in the retail industry in order to identify specific types of workplace hazards.

Methods. Workplace deaths reported to the Bureau of Labor Statistics's Census of Fatal Occupational Injuries from 1992 through 1995 were examined. The retail industry was identified using Standard Industrial Codes 5210 through 5999; types of retail establishments were further divided by SIC. Characteristics of deaths including age, gender, occupation, activity, and type of injury were compared between retail and other industries.

Results. The three leading causes of workplace death in the retail industry were violence (69.8%), motor vehicle crashes (18.9%) and falls (3.1%). Workers killed in the retail industry were 9.0 times more likely to die because of a violent event than workers in other industries (95% CI = 8.38 - 9.66). Although violence-related deaths decreased slightly over the study period they remain the leading cause of retail deaths. Among different types of retail establishments deaths attributable to violence ranged from 22.4% (building supply) to 98.9% (liquor stores). Females, younger workers, occupations dealing with money and the public were at highest risk of a violence-related death. Risk factors, types of injuries, and activities during injury will be examined in the presentation.

Discussion. Workers in the retail industry are at lower risk of most types of workplace deaths but have a markedly increased risk of death by violent means. As workplace violence becomes a larger proportion of workplace deaths and the industries at greatest risk of workplace violence increase in number and size, prevention

measures will need to be identified and evaluated. Prevention measures must be flexible to fit a variety of workplace settings.

Fatal Occupational Crushing and Amputation Injuries in Scrap Balers and Compactor—Moore PH, Smith EO

Purpose. Scrap balers and compactors reduce large amounts of solid waste to small units by means of powered rams or compacting panels. These machines are used by manufacturing companies to handle large amounts of scrap and waste materials such as paper, cotton and metals, by retail and service establishments to compress paper and cardboard boxes, and by government agencies for refuse collection, disposal and recycling. Stationary compactors and balers are commonly used in recycling centers, manufacturing facilities, and retail stores, while mobile compactors are used in refuse collection. The goal of the presentation is to describe the circumstances and risk factors associated with crushing and amputation injuries due to baling and compacting equipment, and to provide recommendations which employers and workers can use to prevent future injuries.

Research Data. Data sources were the National Traumatic Occupational Fatalities (NTOF) surveillance system, the Census of Fatal Occupational Injuries (CFOI), and the Fatality Assessment and Control Evaluation (FACE) project. NTOF is based upon death certificates, CFOI identifies fatalities through multiple sources, and FACE combines surveillance of occupational fatalities with site investigation of selected fatality types.

Hypothesis. Crushing and amputation injuries sustained due to baling and compacting equipment are preventable. Determination of circumstances and identification of risk factors can lead to the development of prevention strategies.

Method. Fatalities were identified through key word searching of all three databases and were further classified by machine type (stationary or mobile). Field investigations conducted by the New Jersey FACE program evaluated the circumstances of three of these fatalities. Risk factors identified were addressed by the development of recommendations for injury prevention.

Results. The NTOF identified 58 fatalities involving compacting

and baling equipment occurring between 1980 and 1992. Mobile compactors contributed to 31 of these deaths. CFOI data for 1992 to 1994 included 18 fatalities. FACE identified 9 fatal incidents in 7 states due to crushing or amputation in compactor or baling equipment; all but one were stationary machines. A large proportion of the fatal injuries occurred when the victim was caught by the ram (platen) while inside the baling chamber, resulting in amputation or crushing injury. These incidents usually occurred during attempts by the victim to free jammed material inside feed chutes of operating machines. FACE data shows that these fatalities frequently occurred when appropriate hazardous energy control procedures were not implemented during servicing of the machine to clear jammed material. At least two incidents occurred when victims fell into the balers, unknown to their co-workers. Risk factors include failure to de-energize equipment before servicing, lack of hazard recognition on the part of the victim, bypassed or inoperative control interlocks or other safety features, unsafe means of access to the inside of the machine for servicing, and lack of a system to account for the location of workers.

Conclusion. Fatalities due to baling and compacting equipment could be reduced or eliminated if employers and employees would implement and follow appropriate hazardous energy control procedures. Prevention strategies include de-energization of machines prior to and during servicing, provision for safe access to feed chutes and hoppers for clearing jammed material, and compliance with consensus standards.

Factors Limiting the Use of Frame Deflection Monitoring to Predict Material Jams in Baling Equipment—Etherton J, Moore P, Harris J, Zeng S

Recent NIOSH fatality investigations have shown that workers risk amputation and crush injury while attempting to clear jammed material from the loading chambers of operating baling equipment. This type of jam occurs when material fills the gap between the edge of the baler's platen (ram) and an interior wall of the loading chamber. Typical hydraulic actuated cardboard balers generate 50-70,000 pounds force which tends to shear material lodged in the platen-edge internal-wall gap.

This study evaluated the feasibility of developing a process monitor to detect and warn workers of impending jams. A proposal was made at NIOSH that signals generated by strain gage transducers, placed at locations on the machine's frame experiencing large deformations preceding jams, could be used to interrupt platen movement; warn of impending jams by triggering alarms; shut-down the machine; or otherwise provide a new safety control.

A system safety analysis using FaultREASE software was conducted to describe the sources of variation in operating conditions that could confound the transducer response of the proposed safety device. Adequate signal conditioning is also needed to adjust for the effects of temperature differentials, vibration, electromagnetic interference, and other factors present in the indoor and outdoor operating environments typical for these machines. Limiting factors that reduce the precision of monitoring with a single transducer in

a complex operating environment were evaluated.

The study concludes that mechanical blocking of the platen and proper lockout/tagout should remain the primary control of hazardous energy to prevent baling-equipment-related amputation and crushing injury.

Work-Related Back Injuries in Retail Merchandise Workers—Gardner LI, Collins JW, Johnston JJ, Landsittel DP

Back injuries are the single most costly workplace injury and have received much attention in workplaces which require frequent heavy (>25 pounds) lifting. However, in the retail merchandise industry, weights of merchandise are generally modest and seldom above 25 pounds, suggesting that material handling-related back injuries might be of lesser importance relative to trauma-related causes of back injuries. In a typical retail merchandise store, causes of trauma-related back injury include falls associated with the use of ladders, wet surfaces, and being struck by falling merchandise. All of these factors suggest the potential importance of trauma-related back injuries. This analysis documents the distribution and determinants of material handling-related and trauma-related back injuries in this large and growing segment of the workforce. As part of a larger prospective intervention study, the authors collected workers' compensation and payroll data from 51,363 store workers in 97 stores (of the same chain) over a 10-month period in 1996 and 1997. Strain or sprain of the back associated with material handling was the most frequent back injury: 269 of 350 back injuries (78%). Trauma-related back injuries, which included caught by/between, struck by, miscellaneous, slip, trip, or fall accounted for 81 (23%) of the total back injuries. Days off work, a measure of severity, suggested material handling-related injuries were more severe (31% with 1 or more days off), compared with 17% with 1 or more days off for trauma-related back injuries.

The risk factor profiles were similar. In both material handling-related and trauma-related back injuries, less experience on the job was strongly associated with a claim, after adjusting for age, job title, and sex using a Poisson regression model. For material handling-related back injuries, the rate ratio was 2.75, $p < .0001$ for workers with 2.2 months or less of experience compared to those with 10.7 or more months of experience. For trauma-related back injuries for the same groups, the rate ratio was 3.00, $p < .01$. Sex and age were not significant risk factors for either material handling or trauma-related back injuries. The excess risk of material handling-related back injuries for stockers and receivers compared to workers who only occasionally perform material handling tasks (rate ratio = 1.75, $p < .0001$) was similar for trauma-related back injuries (rate ratio = 1.58, $p = .09$). The only really important difference in the risk factor profile was that the material handling-related back injuries for workers with intermediate levels of job experience (between 2.2 and 10.7 months) had rate ratios above 2.0, but for trauma-related back injuries the rate ratios for the same categories of experience were below 2.0. In summary, we found that the majority of back injuries in these workers were related to material handling and that the severity level for material handling back injuries was higher. But the similarity of risk factor profiles suggests that prevention efforts, whether directed at material handling or at trauma hazards, could be directed at the same workers (stockers and receivers with the least job experience) for the biggest return per dollar of prevention effort.

Session 32: Mining Safety

Enabling Technologies for Reduced Exposure Mining—Welch JH

Between 1986 and 1995, there were 337 deaths and 72,748 severe injuries to workers in underground U.S. mining operations. Many jobs in an underground coal mine are clustered around the area where machinery digs coal from the surrounding rock, called “the face”. The potential hazards in this area are numerous: When the coal is removed, the ground around it becomes unstable and can cave in on workers. The mining machinery used there are large, heavy, powerful, and move in different directions in a very confined space, presenting danger to workers. The machines churn up coal dust that causes black lung and generate noise that causes hearing loss.

The NIOSH, Pittsburgh Research Center, recently completed a research program to develop enabling technologies that might substantially reduce worker exposure to face hazards in underground mines by relocating equipment operators to an area of relative safety and health. This reduced exposure mining concept is an alternative approach to other safety and health research efforts to reduce potential health hazards such as dust and noise exposure and to reduce accidents in the work place. In this research program, sensor and computer technologies have been developed to allow remote control of mobile mining equipment, specifically continuous mining machines and haulage systems, in the face area. This paper describes these technologies for reduced exposure mining, many of which also have non-mining applications for worker safety and health.

Safety Issues and the Use of Software-controlled Equipment in the Mining Industry—Sammarco JJ, Kohler JL, Novak T, Morley LA

Software-controlled equipments are increasingly employed in mining, because of its ability to effectively solve complex industrial control problems. For mining, the human element is almost always involved and, therefore, safety is critical. Software control is relatively new to mining, and this industry can benefit from lessons learned from applications in other industries. These include guidelines, methods, and processes for safety-critical software and systems. Accordingly, the National Institute for Safety and Health (NIOSH) has initiated a project to address processor-controlled equipment safety. A systems-level approach has been taken. A panel from industry, academia, and other agencies has provided project input. Software development and human-machine interaction were identified as the leading concerns of the panel. Additionally, extramural activity was established with The Pennsylvania State University and The University of Alabama to survey and analyze mining equipment and processes. These researchers met with manufacturers, the Mine Health and Safety Administration (MSHA), and mine operators. Their findings and recommendations are given in the paper, and include issues involving hardware, training, human factors, documentation, software, and compatibility. More than 200 standards and guidelines have been reviewed for applicability to mining, and an identified select list is presented. A framework for system and software safety guidelines has been investigated for mining applications, and this information

is used to conclude the paper.

Reducing Acute Injury From Mine Roof Failures During Remote-Control Mining of Extended Cuts—Bauer ER, Steiner LJ

Underground coal mine workers are subject to many injury causing hazards, including injuries resulting from falling roof rock. One particular work task that seems to be especially susceptible to accidents from falling roof is the remote-control operation of the continuous mining machine. Remotely-operated continuous mining machines are widely used in the U.S. coal industry and are an essential part of mining extended (deep) cuts. Prior to development of remote control, continuous mining machine operators were located in the deck of the machine and protected by an overhead canopy. The use of remote control has removed the operator from the machine and out from under the protective canopy. The operator is now free to move about and position himself where he can best see the mining operation. While remote control has taken the operator further from immediate face area hazards, it has increased worker crew exposure to known hazards and introduced them to new hazards. Fall of roof and rib as well as interaction with other running equipment are now major concerns for remote-control continuous mining machine operators and others working in the face area. Reducing exposure to these hazards requires a systematic evaluation method to address aspects of work procedures and work environment.

This presentation will address the mine worker population at risk, review the associated accidents and fatalities, and describe the major worker safety issues specific to remote-control mining. In addition, NIOSH roof fall accident prevention research efforts will be described, and the injury/accident prevention techniques being implemented by the mining industry to reduce acute injuries from falls of roof will be presented.

Lower Injury Risk for Underground Low-coal Equipment Operators Using Ergonomic Seat with Viscoelastic Foam—Mayton A, Merkel R, Gallagher S

Operators of underground mobile equipment, particularly shuttle cars, experience significant levels of shock and whole-body vibration (WBV). Research sponsored by the U. S. Bureau of Mines (USBM) has indicated that as many as one-third of underground equipment operators may be exposed to adverse levels of shock and WBV. Moreover, cumulative back, neck, and abdominal disorders are linked to prolonged exposure of equipment operators to shock and WBV. Also, traditional seats on mining equipment are inadequate concerning the human needs of the equipment operator. In the extreme, a mining vehicle seat has sometimes consisted of a bent steel plate bolted to the machine frame or hard rubber on a steel bench. Further, restricted space in low-coal mines makes seat suspension systems difficult to use in isolating operators from shock and WBV. The Human Factors group at the NIOSH—Pittsburgh Research Center is responding to these issues with research on viscoelastic foams applied to an ergonomically designed seat. For the full-load case, an ergonomic seat with viscoelastic foam isolated the low-coal shuttle car operator from shock down to 15 Hz. With results from foam testing, an analytical model identified viscoelastic foam capable of lowering the isolation frequency for vehicle shock to below 5 Hz. This paper discusses work that has led to improvements in a low-coal shuttle car seat.

Session 33: Injury Risk Factors for Specific Worker Populations

Analysis of Fatal Injuries 1973-1997 in the Automotive and Other Industrial Sectors Represented by the UAW—Howe J

The UAW has compiled a database of occupational fatalities which occurred in workplaces covered by collective bargaining agreements from 1973 to the present. To date there have been 414 fatalities. Case counts have been made by job classification, industry type and selected agents. Approximate rates have been calculated by industry type. From information collected following the fatality, a summary paragraph has been composed which was the basis for then classifying cases on process risk factors and causal pathways. The most important findings have been the high risk for workers in skilled trades, those that use or work near powered material vehicles and those in production service. Other high risk activities included: demolition, handling heavy items such as steel coils or press dies, and troubleshooting machine failures. There has been a substantial decrease in industry sectors since the implementation of joint health and safety programs.

Effects of Mining Height and Mine Employment Size on Injury Rates in Underground Bituminous Coal Mines—Fotta B, Mallett L

While the effects of either mining height or mine employment size on injury rates in underground coal mines have been examined separately, the present study attempts to examine the joint contribution of these two variables to the risk of injury to an underground miner. Using the mine-level employment and injury data reported to the Mine Safety and Health Administration (MSHA), mines were stratified by average coal seam height (<43 inches, 43-60 inches, and >60 inches) and by the average number of employees working at the mine (<20 employees, 20-49 employees, 50-99 employees and 100+ employees). The employment data show that as the number of employees increases, the proportion of hours worked in low seams decreases substantially. Additionally, miners injured in small low seam mines are, on average, younger and less experienced than miners injured in large high seam mines. Nonfatal and fatal injury rates were computed within each category of employment size and seam height for the major types of accidents (ground falls, powered haulage equipment, machinery, handling materials, slips and falls, hand tools). To reduce the confounding effects of mining method on injury rates, mines using longwall mining methods were identified and excluded from analysis. Results suggest that, regardless of the employment size, as mining height increases, miners are at increasingly higher risk of injury from accidents involving shuttle cars and falls of ground. Conversely, as mining height decreases, miners are at higher risk of injury from accidents involving roofbolting machines, load-haul-dump types of powered haulage equipment, personnel carriers, and powered haulage conveyors. On the other hand, regardless of the height of the coal seam, miners working in large underground mines have higher rates of injuries resulting from accidents involving handling materials and nonpowered hand tools, but lower rates of injury from accidents involving continuous mining machines and from fatal accidents involving falls of supported mine roof. As expected, injury rates for accidents involving a slip or fall increase as the seam height increases. However, the rate of injuries due to slips or falls also increases as the employment size increases. Finally, miners work-

ing at small mines in low or medium seams are at higher risk of being fatally injured by a fall of unsupported mine roof. These results suggest the importance of considering the working height of the mine as the well as the employment size of the mining operation when developing intervention strategies to reduce injury risk to underground coal miners. Results also identify the need to further explore how mining height contributes to the frequency and severity of injuries.

Risk Factors for Injuries Among Veterinarians in Minnesota—Gabel CL, Gerberich SG, Maldonado G, Robinson RA

Occupational injuries are a major source of morbidity and mortality among all workers; among veterinarians, little is known of the extent of injuries sustained and the major causes of and risk factors for workplace trauma. Veterinarians face many hazards in their daily work including the potential for acute trauma from animal bites, other animal interactions, needle sticks with biologicals or pharmaceuticals, and lifting of heavy objects. Veterinarians share many exposures with agricultural workers, the group with one of the highest occupational injury rates. Based on available data, the injury rate for veterinarians is at least 10 per 100 veterinarians per year and may be as high as 20 per 100 based on a recent pilot study by the investigators.

There were two primary aims for this study: one, to identify the magnitude of the injury problem among veterinarians who practiced in Minnesota during 1996 and, two, to conduct both case-crossover and case-control studies to ascertain the specific risk factors involved. The research design employed an initial survey to ascertain and characterize the cohort, and a case-crossover study on selected risk factors, followed by a nested case-control study among this population.

A survey was sent to all 2,687 licensed veterinarians to ascertain whether they practiced in Minnesota during 1996. In addition, information was collected on type of veterinary work, demographic factors and the numbers and relevant circumstances of injuries, if any, sustained during 1996; eight questions were included to enable a case-crossover analysis of the relation of specific hypothesized risk factors to injury occurrence. The response rate to the initial mailing was 62%; a second mailing of the survey is underway which will be followed by a third mailing involving a brief questionnaire to identify minimum information on exposures and injury experience.

From the identified cohort of veterinarians who practiced in 1996, cases and controls will be selected for a nested case-control study. All injured persons will be selected as cases; controls will be selected from among the population at risk. A mailing to both cases and controls will include a comprehensive questionnaire designed to elicit specific information on potential risk factors that will enable comparison of the exposures between these groups and ascertain the major risk factors associated with injury. This mailing will be initiated in June, 1997. Preliminary results will be available at the time of the conference.

A validation substudy will be conducted among a random sample of 10% of the cases and controls, through a review of medical records.

This study design will allow us to calculate the rate ratios for the exposures of interest related to the risk of injury and evaluate po-

tential confounding variables. We will also have a comparison of the results obtained via the traditional case-control study as contrasted with the case-crossover study. Multivariate analysis (conditional logistic regression) will be presented to examine the relation between specific risk factors or protective factors and the occurrence of veterinary work-related injuries.

Case-Referent Study of Injuries in the Wood Products Industry—Punnett L

A case-referent study was carried out of risk factors for injuries to workers in sawmills and other wood product manufacturing facilities to identify ergonomic, safety, and organizational causes of injury in the work environment. A population-based, case-control study design was employed, in which all First Reports of Injury from the wood products industry to the Workers' Compensation Commission in the state of Maine were identified as potential cases. Controls were randomly selected from production workers in participating workplaces and union locals. Interviews of 157 cases and 251 controls obtained information on demographics, work history, usual production tasks, equipment and tool characteristics, and physical and psychosocial features of the work environment. Workplace characteristics were obtained from supplementary databases. Crude odds ratios and multivariate logistic regression analyses estimated associations with task and work environment factors. Among the interviewed cases, about one-half of the lost-time injuries were acute traumatic incidents and one-half were musculoskeletal disorders. Cases were more likely than controls to be employed in machine-paced jobs, to experience louder noise levels and faster work pace, to have higher lifting demands and more frequent postural stress, and to experience lower decision latitude and social support at work. The three strongest risk factors in the multivariate models were processing of hard wood (vs. soft), working in earlier stages of production (eg., sawmills), and high physical demands. Decision latitude and social support appeared to have small protective effects. The other variables that were significantly associated with injury occurrence in the multivariate analyses were being male, having one year or less on the current job, inability to take a break when tired, and a lockout/tagout program in effect. Inferences from these results may be limited by the potential for information bias and for non-representative participation of workplaces and of individuals. Nevertheless, the evidence suggests that many work-related injuries in sawmills and other wood processing plants are preventable. High physical work load, noise levels, machine-pacing, production quotas, decision latitude, and the quality of supervision can all be addressed by proper engineering and administrative organization of the workplace. The higher risk for workers with low seniority suggests a healthy worker effect in the study population or an effect of less experience with actual job conditions, or both; to the extent that the latter is true, training and other programs targeting the newer worker might also help to reduce injury rates.

Session 34: Safety Communications and Training

Educational Programs for Musculoskeletal Work Injury Prevention—Bohr PC

There is a rising trend toward disability associated with work-induced trauma. The need for valid preventive measures is apparent. Prevention intervention programs have been established and widely

implemented, but not well documented or regarded. Training and education programs are considered to be an essential component of prevention strategies aimed at reducing musculoskeletal injuries. With the current emphasis on worker education and the shift into a managed care environment, there is a need to demonstrate the value of current educational programming for prevention of injury.

The purpose of this survey research was to create a data base of available musculoskeletal work injury prevention programs including information on program content, program parameters, and methods of evaluation to assess effectiveness of the programs. Based on a thorough literature review, a scripted survey with structured open ended questions was created. The questions were used to obtain respondents' answers and explanations without bias or limits imposed by the researchers. The scope of the survey included type, method of construction or philosophy, content, pre-program data collected, intended outcome, effectiveness of the program, and how the program was evaluated.

A list of companies offering musculoskeletal injury prevention programs was compiled from the Internet and through personal contact with experts in the field. Of the companies identified, ten met the inclusion criteria that they offered musculoskeletal injury prevention programs which specifically targeted the worker and that they were willing to participate in the telephone survey. A representative from each company answered survey questions and provided information. Responses from each participating company were typed and sent to the company for verification and accuracy. The descriptive information from the survey was then assimilated into common categories.

The results of the surveys indicated a tremendous variability in programming and evaluation. Programs differed in terms of program mechanics, presentation styles, content, and intent. Although there is some agreement that educational programs are important components of injury prevention, there was an overall lack of evaluation measures to assess the effectiveness of educational programming as a prevention strategy.

This presentation will provide an overview of survey results. Based on the information collected and review of literature, recommendations for the design of programs and measurement of effectiveness will be given.

Promoting Safety and Health in Vocational, Industrial, and Technical Education Programs: Guidelines and Curricula

Palassis J

Accident statistics indicate that in any given year, approximately half of occupational injuries are sustained by employees with less than one year of job experience. NIOSH estimates that in the USA 200,000 adolescents suffer work-related injuries each year, out of them, 64,000 require treatment in hospital emergency rooms, and 70 die of work-related injuries. More than half of the injured adolescents reported that they had not received any training in how to prevent the injury they sustained. Adolescents have a high risk for work-related injury compared with adults. There are more than 11 million students that attend vocational/ technical schools in the USA, and the majority of them are employed after school hours.

The purpose of this NIOSH-EID project is to increase the safety awareness and safety education of the vocational school teachers

and administrators so that information can be passed on to the students during vocational training and prior to entering the work environment; to produce informed students capable of recognizing, controlling, and remediating vocational safety and health hazards, applying safe work practices, and consequently becoming safer future workers.

The methods of this project are accomplished via partners who: 1) develop, and evaluate safety and health curriculum materials and student learning activities, including intervention and prevention programs for injury and illness in vocational schools; 2) collaborate with vocational associations and agencies to develop, endorse, promote, and support national safety and health curricula and guidelines for all vocational schools. 33 general safety and health modules relating to vocational shops are under various stages of development and evaluation. Additional modules will be developed in the next two years. The finalized products are compiled into an instructors' training resource manual. They are also electronically being installed and featured in the Internet in the NIOSH Home Page. Video training materials and interactive CD-ROMs are planned to be produced. Working with partners in safety and health education, the products are being disseminated and evaluated. Implementation of safety and health curricula and guidelines will be monitored through the departments of education in every US state and territory. Much work is needed to develop and evaluate the 50+ remaining curricula. The effectiveness of the program will be evaluated via multiple surveys. Close monitoring of injury statistics of adolescent workers over the period of next 10+ years will also indicate the efficacy of the program.

Makin' it Real: How to Develop Effective Educational Methods and Materials on Workplace Health and Safety for Adolescent Workers—Brown MP

Introduction. Occupational injuries for teenage workers is a serious problem in the United States. OSHA estimates that 200,000 adolescents suffer such injuries/illnesses each year; 64,000 of these end up in the emergency room and 70 die from work-related injuries. Most young workers receive little or no health and safety training from their employers or at school. Many of these injuries occur in the workplace where employers are violating safety and health or child labor laws.

Purpose. The aim of this presentation is to describe methods one NIOSH-funded young worker project used to tailor educational methods and materials to the needs/interests of 9th graders in one high school's required education and career planning class. These health educators will discuss how to make such materials useful/relevant, culturally sensitive, highly graphic, and "hip."

Results. The authors will analyze what worked and what did not as they involved their target audience in educational methods and materials development. They will talk about the need to incorporate other related issues—such as sexual harassment, workers' compensation and child labor laws—into a health and safety educational program and how they accomplished this.

Conclusions. How to insure the adoption of these lesson plans and materials by other schools and employers will be discussed. How the lessons learned from this project can be applied to adult worker health and safety education and materials development also will be examined.

Determining the Safety and Health Curriculum Needs of Secondary Vocational Agriculture Teachers: A Collaborative Approach—Thompson RW, Shiflett S

There is not an effective, systematic approach to agricultural safety and health education for secondary students in the United States. To address the problem, the Teaching Agricultural Safety to Kids program at the University of Missouri-Columbia surveyed 260 secondary agriculture teachers to determine their need for safety and health materials in eighteen subject areas. Findings from the descriptive study were used to guide the development of safety and health instructional materials, including student reference guides, teacher demonstrations, and student competency assessments. A four-step process was used to develop the safety and health instructional materials: Needs Assessment-Development-Technical Review-Evaluation. Professionals that collaborated on the project included secondary agriculture teachers, public health professionals, extension staff, state education personnel, agricultural safety specialists, agricultural education staff and private industry safety engineers.

Session 35: Injuries and the Military

Use of Surveillance Databases for Analytic Research: Hospital Databases in the Army—Smith GS, Lincoln AE, Baker SP, Forney CK

Introduction. Hospital discharge databases are an important tool for injury surveillance research. However, they usually measure prevalence rather than incidence of hospitalized injuries because the lack of personal identifiers prevents identification of duplicate admissions for the same problem. Linkage to other exposure data and the ability to follow individuals over time is also not possible with most hospital discharge data.

Purpose. This study seeks to demonstrate the value of hospital discharge data for: identifying injury priorities; evaluating injury risks between males and females, controlling for exposure; and conducting case-control or cohort studies to evaluate injury risks.

Method. Hospital discharge data were analyzed from 1982 to 1994. These now contain a scrambled social security number that permits identification of individuals and linkage of admissions over time. Causes of injury are available on all admissions using STANAG E-codes, a modified E-code with more detail on military hazards. Demographic data on rank, occupational title, length of service, and other data are used to calculate person years of service. Injury rates are calculated to include adjustment of injury risk by exposure as measured by occupational title. Repeat hospitalizations for the same injury can be identified and cohorts of people followed over time. For example, data on all homicides occurring to women in the military are being linked to hospital discharge data to examine if these women have higher rates of prior injury hospitalizations. Analysis by injury type will be used to develop a predictive index of risk of subsequent homicide for specific hospitalizations.

Results. Injury hospitalization rates were higher in men than women (16.1 vs 11.0/1000 PY) while musculoskeletal hospitalizations were higher in women (27.2 vs 34.4). Musculoskeletal problems (ICD Code 710-730) are an increasing problem in the Army with hospitalization rates that are increasing while injury hospitalizations (ICD

800-999) are decreasing. Internal derangement of the knee (ICD 717) is the leading musculoskeletal conditions with higher rates in men than women and much higher rates in the Army (28.5/100,000 population) than comparable civilian data for Maryland (7.7/10,000). Potential reasons for this difference will be discussed as will the relationship between these conditions and old injuries. Males were more frequently hospitalized for athletic and fighting injuries while women had higher rates of poisoning and toe deformities. Further analyses of male/female rates adjusting for occupation will be presented. We will also illustrate how the hospital discharge data can be used for more detailed analytic studies. An example using the predictive risk index for homicide will be discussed.

Conclusion. Hospital discharge data are useful to identify new problems such as increasing musculoskeletal hospitalizations. The existence of unique identifiers also greatly increases the unity of hospital discharge data for injury research. Much can be learned regarding the further potential of hospital data for occupational injury research using military data which has the capacity to link discharges with other databases

Traumatic Injuries in U.S. Army Infantry Trainees—Canham ML

Physically demanding occupational training (e.g., police, fire, and military) can result in a high incidence of injury. We conducted a study to quantify injury incidence and determine potential risk factors during U.S. Army basic infantry training. Medical records and physical fitness test scores were obtained for 197 male trainees. In one company, there were a total of 315 clinic visits during the first 11 weeks of training; 25% (124) of the visits were for traumatic injuries, 39% (79) for overuse injuries, 34% (107) for illnesses, and 2% (5) for other reasons. Traumatic injuries with the highest incidence included sprains and abrasions or lacerations. Overuse injuries with the highest incidence included musculoskeletal pain, strains, and retropatellar pain syndrome. The overall incidence of traumatic injuries in this company was 6.4/100 trainees/month; the overall incidence of overuse injuries was 10.0/100 trainees/month. Risk of sustaining an overuse injury was associated with lower fitness level upon entry to training as measured by pre-training two-mile run times (RR=2.5, $p=0.01$, 95%CI=1.2,5.6). This association was not as strong for traumatic injuries (RR=2.1, $p=0.10$, 95%CI=0.8,5.5). When injury incidence was compared across fitness levels, slower runners were more likely to sustain traumatic and overuse injuries (chi-square for trend=3.0, $p=0.08$; chi-square for trend=9.6, $p=0.002$, traumatic and overuse respectively). In conclusion, injuries accounted for approximately two-thirds of all clinic visits made by the Army infantry trainees studied and trainees that were least fit upon entry to training were at a greater risk of sustaining either a traumatic or an overuse injury.

Risk Factors for Occupational Disability Resulting from Knee Injuries in the United States Army—Sulsky SI, Amoroso PJ, Mundt KA

The United States Congress established the Defense Women's Health Resource Program (DWHRP) to better understand health and combat readiness issues specific to women in the military. One project sponsored by DWHRP was the Total Army Injury and Health Outcomes Database (TAIHOD), developed at the US Army Institute of Research in Environmental Medicine, in Natick, Massachusetts. TAIHOD links demographic, occupational, hospital-

ization, disability, fatality and other data sources on all active duty personnel between 1/1/79 and 12/31/94, and the database is updated annually. More than 2.3 million individuals are included in the database; 11.8% are women. The database is unique in that it includes large numbers of women in various occupations, many of which have no civilian counterpart.

One of the first epidemiological studies to utilize TAIHOD is a case-control study of general and gender-specific occupational risk factors for disabling knee injuries. This study is underway, as of April, 1997, at the University of Massachusetts. Based on the TAIHOD, nearly 9,000 disability determinations for knee problems were made over the 15 years covered; nearly 1,000 of these determinations were for women. In this study, cases were defined as all enlisted women and a random sample of 1,000 enlisted men receiving a disability determination between 1980 and 1994. Disability cases were chosen over injury cases for two main reasons: first, disability generally will be designated for each soldier only once, making it possible to identify "incident" disabilities (unlike injury records, which may be for incident or recurrent events, or may go unrecorded); and second, disabled cases indicate a minimal level of severity. Controls were defined as a random sample of 3,000 enlisted women and 3,000 enlisted men selected by calendar year in proportion to the cases, thus approximating a density sampling approach.

We will use multiple logistic regression procedures to compare cases and controls with respect to demographic and occupational factors such as race, age, rank, duration of service, and Military Occupational Specialty code (from the personnel database) and numbers and types of hospitalizations and accidents (from the hospitalization and safety databases) occurring during the follow-up period. Follow-up begins with the enlistment date or 1/1/80, whichever is later, and ends in the year of the disability determination for the case. These basic analyses will be augmented by analyses focusing on the specific types of knee injuries or conditions leading to disability. All analyses will be stratified by gender, since a primary goal of this study is to fully understand the differences in gender-specific risk factors for disabling knee injury.

A preliminary analysis of Army disability data for 1990-1994, only, has revealed that differences in the risk of serious knee injury by gender and job type may exist (Feuerstein, 1997). Understanding gender differences in risks for occupational disability should lead to increased injury prevention through appropriate training, education in injury prevention, and improved ergonomic design of equipment. Since women are employed in a vast range of non-combat occupations in the Army, the benefits of such investigations reach beyond military services into civilian populations.

Maritime Preventive Medicine Program. Discussion of the U.S. Coast Guard Initiative for Occupational and Environmental Health and Safety Concerns Affecting the Nation's Maritime Industries and Workers—Ungs TJ, Adess M

Background. The Bureau of Labor Statistics and NIOSH have identified the maritime industries, particularly fishing, as among the nation's most dangerous. Data compiled by Coast Guard mishap investigation and reporting systems underscore the major economic, environmental, and human costs incurred by marine vessel and personnel casualties.

NOIRS Abstracts

Work-related health hazards affecting maritime workers are not well characterized. The magnitude and extent of morbidity and mortality affecting most maritime subcomponents are not known. An unique aspect of maritime occupations is that vessels serve simultaneously as work place and home. Living space and work spaces are often compressed, may be in-common, and physically exist in close proximity to cargo, fuel, propulsion, and storage spaces. Ventilation, water, sanitation systems may cross-link or be shared between living and other vessels spaces. The maritime environment is often treacherous, presents the extremes of weather, is inherently unstable, and is often isolated.

Assessment and remedy of occupational maritime health and safety issues are problematic. The commercial maritime arena is comprised of a diverse set of industries and communities ranging from owners/operators of international bulk freight vessels to off-shore oil platforms to three member shrimp boats. The historic development of maritime commerce, law, and ship-crew relationships are

different from those of land-based analogues. In addition, the ready movement of vessels across state and national boundaries and shifting economic stability compound understanding and approach.

Discussion. The purpose of the Coast Guard program, "Maritime Preventive Medicine" (MPM), is to provide focus to identify, assess, and prevent occupational-related health and safety problems in the maritime arena. MPM has three major action areas: 1) develop an academic, government, and industry collaboration titled "Partnership in Maritime Medicine"; 2) team with key organizational elements within the Coast Guard and elsewhere; 3) develop a WWW-based information system on maritime occupational and environmental health and safety.

The presentation will provide background information, describe the purpose and activities of the MPM initiative, outline where the program seeks to proceed, and discuss potential opportunities.



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